

**A DECISION SUPPORT TOOL TO AID
CAMPAIGN PLANNERS IN SELECTING
COMBAT AIRCRAFT FOR THEATER CRISIS**

THESIS

**Christopher D. Buzo
First Lieutenant, USAF**

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March 1, 2000

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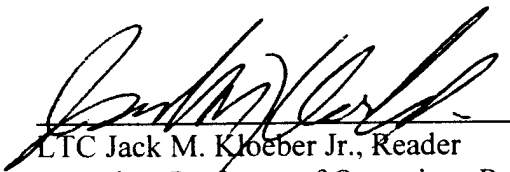
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ABSTRACT

One way of comparing alternative deployment plans is to examine how combat aircraft tasked within a deployment plan meet the combat commander's requirements. Both the absolute capabilities and the campaign-specific issues affecting the operational capabilities of those aircraft could assess a set of combat aircraft, unique to a deployment plan. This research develops a non-absolute, campaign-specific decision support tool to assess the effect of campaign-specific issues on a set of deployable Air Force combat aircraft.

This research is conducted in three phases. Cognitive Task Analysis (CTA) and Multi-Attribute Preference Theory (MAPT) methodologies are applied to in-person and telephone interviews with subject matter experts (SMEs) on USAF wartime planning. The information is then consolidated to develop a Value Focused Thinking decision support tool. This tool is developed with contingency planners at the United States Air Force's Central Command Headquarters. The decision support tool is verified through a Delphi study with the previously identified SMEs.

The results of this research provide campaign planners with a decision support tool to assist in selecting a set of USAF combat aircraft best suited to deploy in response to a SWA Theater crisis, based upon the current environment within the SWA Theater.

*If I always appear prepared, it is because before entering an undertaking,
I have meditated for long and have foreseen what may occur.
It is not genius which reveals to me suddenly and secrecy
what I should do in circumstances unexpected by others;
it is thought and preparation.*

Napoleon Bonaparte

A DECISION SUPPORT TOOL TO AID CAMPAIGN PLANNERS IN SELECTING COMBAT AIRCRAFT FOR THEATER CRISIS

I. INTRODUCTION

Background

The Advanced Logistics Project (ALP), a Defense Advanced Research Projects Agency (DARPA) skunkworks, is currently developing a distributed computing architecture that will create a near-real-time deployment planning process for military forces. This deployment development and implementation architecture (computer software program) will enable logistics planners from the US military services to quickly and efficiently develop and implement a situation-tailored logistics plan. One important issue that the ALP has not yet resolved is the ability of the architecture to choose a particular logistics plan from among a set of similar alternative plans. Consequently, ALP has requested the support of both the Air Force Institute of Technology (AFIT) and the Air Force Research Laboratory (AFRL) to develop a methodology for rationally measuring the relative contribution of each alternative deployment plan toward satisfying a given combat commander's time-phased campaign objectives. Both AFIT and AFRL are taking a United States Air Force (USAF) focused view to the research. If a methodology can be developed to rationally measure the relative contribution of individually specific combat equipment to a particular deployment plan, then this methodology should be expandable to incorporate not only USAF combat assets but Army, Navy and Marine Corps combat assets.

One plausible method of assessing the relative contribution of a unique deployment plan centers on the specific set of combat aircraft tasked within each alternative deployment plan to meet the combat commander's requirements. The purpose of a USAF deployment plan is to provide the combat commander with the combat aircraft, and necessary supporting equipment, to meet the required objective. Therefore, a specific set of combat aircraft assets that is best suited to meet the needs of the combat commander, versus other unique aircraft asset sets, would be one way of identifying the best deployment plan. This, of course, assumes that each of the competing deployment plans are otherwise similar and that all of the competing deployment plans could be successfully implemented.

When comparing competing sets of combat aircraft assets, a first concern is ensuring that the aircraft comprising the set are capable of performing the aerospace missions required by the combat commander. Each specific combat aircraft has been designed and developed with an *absolute* capability to perform one or more specific aerospace missions. For example, the absolute capability of the F-15, C/D model is to conduct *Air Interdiction* missions. The absolute capability of an F-16, C model, however, can conduct *Suppression of Enemy Air Defense*, *Air Interdiction*, and *Surface Attack* missions, just to name a few. However, only looking at the absolute capabilities of the combat aircraft within the asset set may not satisfactorily evaluate comparable asset sets, as many of today's USAF combat aircraft can be equipped to complete many of the possible aerospace missions.

Therefore, a second method of comparing competing aircraft asset sets is to study the situation dependent or *contextual* issues that may be specific to the campaign or

theater in which the aircraft asset set will be deployed. While each individual combat aircraft asset may be specifically designed to complete certain aerospace missions, regional or campaign specific issues may drive the necessity to complete aerospace missions with less-than-optimal combat aircraft assets. Constraints placed upon US forces by the host nation or at the staging base within host nation territory may keep campaign planners from selecting certain combat aircraft. For example, host nation political issues may restrict the presence or use of combat aircraft perceived to be 'offensive', or nuclear capable. Campaign specific issues such as these may be a very important concern to the campaign planner in selecting the best aircraft to conduct the required aerospace missions. Above and beyond the capabilities of specific combat aircraft to complete aerospace missions, campaign specific issues may be an important driver or limitation to specific sets of combat aircraft that can be deployed to meet a theater crisis.

Problem Statement

Given that the Advanced Logistics Project will provide a methodology to quickly develop a detailed deployment plan, campaign planners will have the opportunity to compare multiple deployment scenarios and schedules. How would campaign planners then choose between similar deployment plans? Different deployment plans may call for the selection of different fighter and/or bomber aircraft assets. An assessment could be based upon campaign specific or theater specific issues that may not be addressed by an aircraft's absolute capabilities, but would be nonetheless important to the satisfactory completion of the operational missions required by that set of assets. A particular set of combat aircraft, unique to an individual deployment plan, could be assessed based upon

both the absolute capabilities of the combat aircraft within the particular set and contextual, campaign specific issues that could affect the mission capability of the combat aircraft within the particular set. The focus of this research, then, is to assess the contribution of contextual issues as these issues would relate to and modify the absolute capabilities of the aircraft assets in determining the relative merit, or value, of competing sets of combat aircraft. This research will also develop a decision support tool to provide an automated evaluation of situation dependent, campaign specific issues as they relate to a Southwest Asian Theater, Air Expeditionary Force deployment.

Research Questions

To successfully complete this research project, the following questions must be answered:

1. What factors other than absolute aircraft capabilities should campaign planners consider when selecting a specific set of combat aircraft to counter a theater threat?
2. How are these factors quantified?
3. What relationships link these factors to each other?
4. Based on a Southwest Asia scenario, what is the relative importance of each factor with respect to the others?

Methodology

This research is conducted in three phases. The first two phases include in-person and telephone interviews, conducted with subject matter experts (SMEs) on USAF wartime planning and deployments, using Cognitive Decision Making (CDM) and Value-Focused Thinking (VFT) methodologies. Using the information gleaned from these first

two phases of the research, a Value Focused Thinking decision support tool is developed. This tool is developed with contingency planners at the United States Air Force's Central Command Headquarters (CENTAF). The third and final phase of the research verifies the decision support tool through the use of a Delphi study with the previously identified SMEs.

Assumptions

This thesis research is limited to a United States Air Force, Southwest Asia (SWA) Theater Expeditionary Air Force combat deployment.

The environment in which the military conducts its business is constantly changing, primarily the result of changing international politics and world economics. The findings and conclusions of this research are therefore based on current international politics and business practices, and may not be valid in a different world order. While U.S. forces currently choose to take the lead in international military issues, a shift of our national forces to a supporting role under United Nations (UN) or North American Treaty Organization (NATO) lead campaigns may alter U.S. planning processes. Furthermore, the factors used in the decision support tool have been developed primarily through SME opinion and expertise with respect to a SWA campaign, so the issues and relative valuations obtained here may not apply in another scenario or theater. Because of the joint focus of our forces under complementary missions, it is hoped that the methodology, findings, and conclusions from this Air Force focused research can provide a basis for further research with respect to campaign planning in other theaters and within the other branches of service.

Scope/Limitations

Because of the need to main secrecy within the planning of military operations, portions of Concepts of Operations and Operating Instructions may be classified. In order to keep this effort unclassified, research conclusions will only be considered within the scope of unclassified information.

The focus of this research is to examine the issues or factors not tied to the *absolute* capability of USAF combat aircraft to perform specific aerospace missions that would affect the deployment suitability of particular aircraft assets to counter a theater threat. Because of this, the *absolute* capability of each individual USAF combat aircraft is not considered or studied.

Furthermore, campaign specific issues, not tied to the *absolute* capabilities of combat aircraft assets, may vary from theater to theater; therefore, this decision support tool research focuses only on the SWA Theater. The Expeditionary Aerospace Force concept was developed largely because of ongoing commitments in the SWA Theater. Therefore, campaign planners within today's Concepts of Operations can most effectively apply a decision support tool based upon the SWA Theater. However, the campaign specific issues identified in this research may be important in other theaters.

Summary

This chapter provides the motivation behind the development of a United States Air Force campaign-specific decision support tool to help campaign planners select the best mix of combat aircraft to deploy in response to a theater crisis. One way of comparing alternative deployment plans is to examine how well the specific set of combat aircraft tasked within each deployment plan meets the combat commander's

requirements. A particular set of combat aircraft, unique to an individual deployment plan, could be assessed based upon both the absolute capabilities of the set's combat aircraft, and the campaign specific issues that could affect the operational capabilities of the combat aircraft. This research develops a non-absolute, campaign specific decision support tool that can be used to assess the effect of campaign specific issues on any candidate set of deployable Air Force combat aircraft.

Chapter II reviews deploying issues as well as the tools and techniques used to elicit information from subject matter experts for developing decision support tools. Chapter III describes the methodology used to elicit deployment factors and develop the decision support tool. Chapter IV develops the decision support tool, and Chapter V provides conclusions and discusses the applicability of the developed decision support tool to both on-going AFIT/AFRL and ALP deployment planning work and Air Force operations planners.

II. LITERATURE REVIEW

INTRODUCTION

The primary mission of the campaign planner is to provide the Joint Air Component Commander with a satisfactory set of combat aircraft to meet required aerospace missions. A set of USAF combat aircraft, or asset set, is defined for the purposes of this research as any combination of fighter and/or bomber aircraft that have the absolute capabilities to satisfy the combat requirements of the Joint Air Component Commander, Joint Forces Commander, and or Theater Commander. When selecting a set of USAF combat aircraft to deploy, campaign planners must take into consideration many unique political, economic, and social considerations, as well as national and international goals. The decisions of these planners may ultimately decide the outcome of the conflict. As this task involves high stress, short time constraints and international politics, experienced planners are essential.

This chapter begins with a presentation of the methodology behind Cognitive Task Analysis and Cognitive Decision-Making methodologies, and why these methodologies were selected. Next, a discussion on Multi-Attribute Preference Theory and Value Focused Thinking and why these methodologies were selected, follow the discussion of cognitive methodologies. This chapter continues with an analysis of the Delphi study technique, which is an iterative survey and reply method that is used to obtain feedback and agreement on the planning factor decision support tool. An explanation of why this methodology was selected is also presented. This chapter concludes with an analysis of the current operational status of USAF deployment theory, and the current level of detail on planning factors presented within Air Force and Joint

Doctrine. Air Force and Joint Doctrine is used as the foundation for understanding of the planning factors that drive the selection of combat aircraft under crisis action planning.

IDENTIFYING THE BEST METHODOLOGY TO ELICIT ISSUES FROM EXPERTS

Several interviewing methodologies were studied to determine which method best suited the initial identification of campaign-specific issues. Knowledge of these issues is limited to a select group of individuals. Furthermore, understanding of how the campaign-specific issues are interrelated and how these issues could be qualitatively measured requires the aid of individuals with experience and knowledge of campaign planning. To identify these campaign-specific issues from campaign planning experts, three elicitation methods were identified for possible use. The first method was the formal survey. The second method studied was the Traditional Task Analysis. The third method identified for use in this study is the Cognitive Task Analysis methodology.

THE FORMAL STUDY

A formal Air Force survey is normally developed, approved by Air Force Personnel Command, and then mailed to an identified group of participants. A survey consists of specific questions, usually developed to be answered using either ranges (worst to best), multiple choice suggestions, or fill-in-the-blanks. Formal surveys often take several weeks to be approved, then over a week to reach all of the participants, and finally several weeks after that to see any responses. In addition to this time constraint, most formal surveys receive responses from at most one-half of the total number sent [Steele; 1999]. A formal survey was not selected as the method to obtain the views and experience from campaign planners.

The formal survey was discounted for three reasons. First, the purpose of the study is to obtain views and experience, which may not be concisely captured in a formal, static survey. The way in which the questions are asked may not elicit the responses necessary to develop a solid decision support tool. Secondly, due to the time requirements of a formal survey, multiple rounds of questions, if necessary to obtain understanding of the issues, would not be feasible. Finally, a formal survey was discounted because of the small number of expert (rank of Major to Colonel) campaign planners actively conducting planning operations.

TRADITIONAL TASK ANALYSIS

Traditional job or task analysis provides a deep understanding of individual jobs, their behavioral requirements, and target performance, which help to create a better understanding of how the individual employees within an organization should function. Traditional task analyses study job tasks in relation to behavior responses that must be made to each stimulus encountered, emphasizing item-specific knowledge [Seamster et al., 1997; pg 5]. First, the specific job must be defined, to include task requirements and people requirements [Cascio, 1998; pg 133]. Descriptions of the job are useful only to the extent that they accurately represent job content, environment, and conditions of employment [Cascio, 1998; pg 137]. The primary method of defining jobs and the specific tasks of these jobs is through direct observation. Using this method, the research would require the unobtrusive observation of an actual real-world or exercise campaign planning process. This method is primarily suited for jobs that require a great deal of manual, standardized, and short-cycle activities, and inappropriate for jobs that require a great deal of mental activity and concentration [Cascio, 1998; 139-140].

The traditional task analysis was discounted for three reasons. First, the methodology emphasizes the behavior of workers performing specific tasks. The focus of this research is on the identification of issues that workers, in this case campaign planners, must appreciate when performing their duties. The focus is therefore completely on the task and not on the behavior of the worker. Secondly, the task of campaign planning is not generally a rigorously manual activity. Conversely, the purpose of this study is to identify campaign-specific issues that require concentration and mental capability to resolve. Lastly, there was not any opportunity during the period of this research to attend either a real-world or exercise campaign-planning operation.

COGNITIVE TASK ANALYSIS

Today's professions often require a level of knowledge and skill that may not be achievable without years of training and practice. However, under many circumstances it is not simply the years of training and practice that make an individual qualified. Often times, organizations look for individuals who have wisdom and experience within their field that cannot be simply memorized from a textbook. Human thought and behavior have a direct impact on the capabilities of an individual, but may be outside the normal perception of job duties. For instance, an airport traffic controller may make hundreds of critical decisions regarding the flow and order of incoming and outgoing aircraft, all of which may go unnoticed to a casual bystander or a trainee. Cognitive Task Analysis (CTA) can be used to study these non-observable skills and cognitive activities. For example, CTA methods can be used to record the air traffic controller's performance and translate or transform it through a systematic process such as speeding up, slowing down, or coding it so a perceptible pattern emerges [Seamster, 1997: pg 25]. The resulting

information or patterns can be used to better understand these non-observable skills or cognitive actions of experts, allowing trainees to learn and improve their performance more quickly than would otherwise be experienced. Therefore CTA methods were selected to perform the first phase of this research.

Methods for CTA occupy a central position in cognitive science, whereby researchers work to uncover the underlying knowledge and thought processes that make experts more valuable than novices. CTA can be used to form inferences about non-observable cognitive activities through the development of an accurate picture of the tasks and environment in which they are performed. According to Klein et al., [1997: pg 1], task analysis methods usually provide a listing of the steps to be followed, but on top of those steps are the difficult and critical decisions that operators must make under restraining conditions. We can therefore see that decision requirements are not limited to choices between options: they can include judgments, situation assessments, and problem-solving activities. CTA methods were selected to perform the first phase of this research. Because experience is a key issue, CTA methods can be applied to elicit information from experienced planners that can then help planners of all levels of experience to make better decisions. Furthermore, a decision support tool can be developed from this cognitive data.

In recent research into the abilities of workers, Ericsson and Charness [1994: pg 725-747] found that expert performance results from increases in knowledge and skill acquired through work and practice. As one might assume, extended training and practice develop and refine memory processes and content in such a way that advances expert performance. Ericsson and Charness's theory of skilled performance provide the

basis for the allowance that CTA can be used to form a more complete understanding of expert performance.

A portion of CTA involves working with contextual experts to determine how they perform cognitive tasks in a superior fashion, but not all contacts need to be actual experts. Analysts performing CTA are collecting information that can uncover strategies that an operator might not be able to articulate [Klein et al., 1997: pg 3]. Useful information can be gleaned from all levels of expertise. By comparing the novice with the expert, the unique characteristics of the expert become more evident [Seamster, 1997: pg 27]. Experts and novices (at a particular task) use knowledge differently. Recent research has found that novices focus on perceptual aspects, whereas experts make deliberations on what they see [Wezel et al., 1996: pg 359]. Experts try to figure out the consequences of certain combinations. Through the understanding of these different levels of knowledge, expertise, and cognitive reasoning, practical training and understanding can be obtained. Routine incidents can often be handled automatically, so the participants, no matter the level of expertise, may not be aware of the types of judgements they were forced to make [Klein et al., 1997: pg 4].

Cognitive Task Analyses are typically conducted in stages to improve manageability and integration of information about sub-tasks within the overall job [Seamster, 1997: pg 43]. Through stage analysis, many cognitive components of a large job can be successfully documented and understood. CTA is not a single methodology applied to the solution of a single problem. Rather, CTA comprises a set of analytic methods and techniques that vary on a number of dimensions, including the kind of data that they produce. CTA includes methods to elicit, analyze, and represent information

about cognitive processes required for proficient task performance [Seamster, 1997: pg 64]. Researchers must select and apply the technique most appropriate for their specific project; often this requires a combination or synthesis of several techniques. When choosing the technique or combination of techniques, a number of important factors must be considered. These factors include the time available to the researcher to conduct the study, the budget allotted to complete the research, accessibility to subject matter experts, and data collection, analysis, and validation methods. The analysis and comparison of these factors to the type of cognitive task to be studied leads to the selection of the analysis method [Seamster, 1997: pg 43-61].

IDENTIFYING THE BEST CTA METHODOLOGY TO ELICIT ISSUES FROM EXPERTS

Three CTA methodologies were identified for possible use within this research. The first methodology is the Verbal Report method. The second methodology is the Simplified Precursor, Action, Result, and Interpretation (PARI) method. The third CTA methodology studied is the Cognitive Decision-Making methodology.

VERBAL REPORT METHOD

The Verbal Report method asks the subject matter expert to provide a running commentary of the actions, re-actions, and thoughts either while conducting the job or after the job has been completed. These verbal descriptions of actions and thoughts are usually recorded for later analysis. Using these recordings, analysts can make inferences about cognitive processes based on the knowledge the subject matter expert articulates during these reports. This type of analysis, if conducted with a number of experts, could identify the campaign-specific issues in question. Unfortunately, there were not any

opportunities to study campaign planners during a campaign planning exercise, nor could the campaign planners be asked to spend time writing down their last campaign planning experience. A group of planners may not have had the same experience in planning campaigns; some may have planned deployments for combat operations while others may have planned deployments for humanitarian efforts. The variability of historical planning and the available time these planners could be required to spend documenting their actions proved the Verbal Report method to be infeasible for this research.

SIMPLIFIED PARI METHOD

The PARI methodology is based on a structured interview process designed to elicit a high level of skill detail. A simplified PARI methodology was adopted by Seamster et al. from the full PARI's time-intensive methodology for use in an operational environment [Seamster et al., 1997; pg 72]. The simplified PARI analysis is based on a structured interview, consisting of problem solving in an operational context. Rather than having an expert talk about performing a task to the researcher, two experts talk to each other while the interviewer watches and listens. While one expert poses a task-specific problem, the other expert solves the problem. Usually the researcher is one of the experts. This method is best suited to tasks that have procedural tasks, such as maintenance operations or computer trouble-shooting. For these jobs, there is usually a specific order in which individual tasks are carried out sequentially.

The simplified PARI methodology was not used for two reasons. First, this researcher does not have the expertise or background knowledge to participate in a PARI analysis, nor is the knowledge present to develop a campaign planning scenario with sufficient detail to identify the campaign-specific issues sought. Secondly, the PARI

methodology is best suited to jobs that consist of procedural tasks. Analysis of campaign-specific issues may not necessarily be an ordered task; therefore the PARI methodology is not the best method to use within this research.

CRITICAL DECISION METHOD

The CTA method used in this research is the Critical Decision Method (CDM). CDM is a semi-structured interview technique, developed by Klein, Calderwood, and MacGregor in 1989 through the continuation of Flanagan's critical incident technique. CDM is a retrospective interview strategy that applies a set of cognitive probes to actual nonroutine incidents that required expert judgment or decision-making [Klein et al., 1989: pg 464]. The interviewing strategy can be used to elicit information about decisions made by experts in any number of field settings. Decision making and problem solving are complex cognitive tasks requiring substantial skills. These tasks lie at the heart of proficient performance and serve to guide the overt motor behaviors that are the meat of traditional task analyses [Seamster, 1997: pg 78]. These decisions often depend on subtle perceptual cues and assessments of rapidly changing events that could not be easily described. Interviews and probes enable experts to focus on and document aspects of job activities and performance that is normally only tacitly understood. This method is used successfully in a number of studies and in widely diverse domains [Roth, 1992; pg 1163]. For these reasons, the CTA method best suited to develop a decision support tool based upon the cognitive knowledge of experts is CDM. The following section discusses the Critical Decision Method as it applies to obtaining cognitive knowledge through interviews with subject matter experts.

The CDM focuses on the previous experiences of subject experts and applies cognitive probes to elicit the expert's decision strategies, perceptions, operational cues,

and errors. The CDM is usually applied through a 'storytelling' interview, guided by the interviewer. Often, interviewers can successfully incite the interviewee into detailing job information through telling a story about the job. This method puts the interviewee at ease about the level of complexity of the interview, and information is often brought to light that may not have been identified had the interviewee been simply asked to point out specific requirements of the job. Knowing the overall type of information needed to conduct the research, the interviewer guides the expert through a particular activity or incident. The interviewer may need to ask numerous questions to extract sufficient information to develop a situation. The interviewer will then use this situation as a framework from which to probe decisions, judgments, and problem solving. One of the most challenging and important aspects of the interviewer's work is to get the respondent to answer the question posed. If the interviewee gives an incomplete answer or misunderstands the question, then it is the interviewer's responsibility to get the interviewee back on track through careful, neutral techniques [Interview Research Manual, 1976: pg 15].

The CDM interview generally consists of four sweeps through an incident or activity. As might be assumed, the first sweep captures the story of the activity. During this section of the interview, the expert relates, in his or her own words, a particular incident that required skill or expertise. This section helps the interviewer to understand the dynamics of the incident, and to determine whether the incident itself is suitable for further examination. The second section of the interview is generally used to develop a timeline for the activity. This section helps to map out the sequence of events within the activity. Inconsistencies, if found, can be identified and discussed. Through the

discussion of activity events in chronological order, more detailed and specific information can be obtained from the interviewee. In the third section of the interview, the interviewer uses cognitive probes to elicit more detailed information regarding decision points. These cognitive probes examine goals, cues, expectancies, courses of action, and required information. During the fourth section of the interview, the interviewer reviews the activity and documentation to discuss any errors; either errors committed by the expert or hypothetical errors that might be committed by people with less experience [Seamster, 1997: pg 185].

While it may seem easy to let the interviewee describe personally experienced incidents, relying on strictly personal experiences can hamper the analysis of performance on more than one incident. It is different to make comparisons among multiple experts when the data collection process probes a unique incident for each interviewee. Exposing subject matter experts to a standard scenario and eliciting their decisions and actions within this scenario can enable the analyst to study the scenario itself.

The issues of reliability, validity, efficiency, and utility of CTA and the CDM have been discussed at length by Hoffman, Crandall, and Shadbolt. Through their research, a case study of the CDM is pursued, proving that the method can be effectively applied as an elicitation method of cognitive requirements for any number of tasks [Hoffman et al., 1998].

Once the campaign-specific issues have been identified through cognitive analysis, these issues should be combined in such a way that the end product provides a net benefit to the campaign planner. The best methodology for assisting the campaign-

planners in making better decisions lies in Decision Analysis methodology. The next two sections of this chapter discuss the field of decision analysis and the methodology chosen for this line of research.

IDENTIFYING THE METHODOLOGY TO CONDUCT A QUALITATIVE ANALYSIS OF THE ISSUES

"Although decision analysis (DA) provides structure and guidance for systematic thinking in difficult situations, it does not claim to recommend an alternative that must be blindly accepted" [Clemen, 1995; pg 4]. This statement summarizes the purpose of the application of decision analysis techniques in the identification and analysis of campaign-specific issues. For this research, continuing cognitive based analyses does not suffice. While CTA principles provided an excellent methodology to identify the campaign-specific issues in question, CDM does not lend itself to qualitative decision support tools. However, decision analysis methodologies can be implemented to provide qualitative analysis of issues, whether deterministic or variable.

Most decision analysis techniques revolve around the comparison of alternatives, and the tradeoff between multiple competing objectives. DA is being used to focus the research on evaluating the possible issues that a campaign planner must consider when selecting combat aircraft in response to a theater crisis, and how these issues will impact unique sets of combat aircraft. A competing objective for campaign planners could be the tradeoff between sheer quantity of firepower and the amount of lift required to deploy the equipment necessary to deliver the firepower. The most important final result of the analysis, however, is not an exact answer to the problem, but instead a ranked ordering of possible sets of assets that can be used to assist the campaign planner in making better

decisions more efficiently. It is for these reasons that Decision Analysis was selected as the methodology to continue the analysis of the campaign-specific issues into the development of a qualitative decision support tool.

IDENTIFYING THE DECISION ANALYSIS METHODOLOGY

Several DA methodologies were initially identified to determine which method best suited the development of the campaign-specific issues into a decision support tool. The first method identified was the Advanced Hierarchy Process (AHP). The second method studied was Value Focused Thinking.

ADVANCED HIERARCHY PROCESS

AHP was developed in 1977 as a decision aid to help solve unstructured problems in economics, social, and management sciences. The methodology enables decision-makers to structure a complex problem in the form of a simple hierarchy and to evaluate large number of quantitative and qualitative factors in a systematic manner under conflicting multiple criteria [Cheng et al., 1999; pg 423]. Use of the AHP methodology involves breaking down a complex problem into small constituent elements and then structuring the elements into a hierarchical form. A series of pairwise comparisons is then made between elements to a ratio scale. The foundation of this methodology deals with individual scales of judgements; comparing several expert's views and judgements made lead to an inconsistent decision support tool. As rankings of the elements are based on verbal values such as "Good" and "Very good", comparing elements is often confusing if not impossible. The decision support tool, as developed, must be easily learned and applied by individuals who are otherwise naive to mathematical

methodologies. For these reasons, AHP was discounted as the methodology for the development of qualitative measures for the campaign-specific issues.

VALUE FOCUSED THINKING

The one essential element of a decision is the existence of alternatives; if you do not have alternatives, you do not have a decision problem [Kirkwood, 1997: pg 2]. In many of today's complex business and operating environments, decision-makers are faced with choosing between several alternatives to maximize one or more objectives. Value Focused Thinking [Keeney, 1992: pg 55] is a very useful technique for decision situations involving multiple and conflicting objectives. Value Focused Thinking (VFT) structures the decision-maker's values and develops a multi-objective decision analysis tool that can be used to both identify alternatives that create value, and to evaluate alternatives. "With value-focused thinking, you should end up much closer to getting all of what you want" [Keeney, 1992; pg 4].

At the heart of Value Focused Thinking is the value hierarchy. Values provide a foundation of interest in any decision situation. Value hierarchies serve as graphical representations of the important considerations that decision-makers will take into account and use to determine the relative value of competing alternatives.

Value hierarchies are used as guides for information collection, to help identify alternatives, to facilitate communications, and to evaluate alternatives [Kirkwood, 1997: pg 19-23]. There are several accepted methods to developing hierarchies. Kirkwood identifies either a bottom-up or a top-down approach as acceptable [Kirkwood, 1997: pg 19-23]. In the bottom-up approach, alternatives are known and can be examined to determine how they differ. Grouping the differences in alternatives together into higher

and higher tiers forms higher level values [Kirkwood, 1997: pg 19-23]. A similar approach, called the *Silver Standard*, identifies and names individual tasks that the organization performs. The named tasks can be grouped together in affinity diagrams and then structured into different value hierarchy tiers [Parnell et al., 1998: pg 1340].

The top-down approach can be used when alternatives are not well specified. Values are built starting at the highest tier and are then broken into successively lower tiers. Typically, information for this method comes from mission, vision or strategic documentation. This process is called the *Gold Standard* in the development of a value hierarchy [Parnell et al., 1998: pg 1338]. The *Gold Standard* can be effectively applied when the organization's top decision-makers can be interviewed.

In either approach described by Kirkwood, values are placed in the hierarchy if and only if value scores for a particular alternative would change the ranking of that alternative in respect to the other alternatives [Kirkwood, 1997: pg 19-23].

An evaluation measure, often referred to as an attribute, is used to measure the degree to which an objective or a value has been obtained [Kirkwood, 1997: pg 12]. Evaluation measures provide quantitative measures for the decision. The evaluation measure converts a quantity from its particular units to a common set of units, thus allowing the many attributes to be combined into a single measure of merit or benefit. A value hierarchy combined with evaluation measures and the weights is a value model. Generally, a value model combines many measures into a multiple objective value function to measure an alternative's attainment of the fundamental objective. Careful development of an evaluation measure is required if it is to provide correct insight to the decision-maker.

According to Keeney, important attributes are those that can be measured and embody appropriate implicit value judgements. They measure what the decision-maker is interested in and do not measure other items. Ambiguity can occur if the attribute levels are not well defined [Keeney, 1992: pg 113]. The clairvoyance test can be applied to help determine whether a measure is ambiguous or not. If a clairvoyant could foresee the future with no uncertainty, that clairvoyant should be able to unambiguously assign a score to the outcome from each alternative in the decision problem [Kirkwood, 1997: pg 28]. If one person assigns a level to an attribute, another person should be able to interpret the attribute level with no loss of information [Keeney, 1992: pg 116]. If the evaluation measure is ambiguous, it will not be understandable.

Kirkwood identifies four different types of scales for measuring values in value hierarchies. A scale can be either natural or constructed, and can be either be direct or proxy. Natural scales are those in general use that have a common interpretation. Constructed scales are developed specially for a particular measure. Direct scales are used to measure the quantity examined. Proxy scales are correlated with the quantity measured, but actually measure something different than the value being quantified [Kirkwood, 1997: pg 24]. Constructed attributes exactly measure what the objective is meant to address. Proxy measures reduce the number of attributes needed for a decision and simplify descriptions of the consequences [Keeney, 1992: pg 118-121].

Measurement theory generally acknowledges five scale classifications. These scales, in order of increasing information, are nominal, ordinal, interval, ratio, and absolute. Table 1 presents the scales, in increasing order of information, along with their definition, common allowable transformation, and example.

TABLE 1 – Measurement Scale Types and Definitions			
SCALE TYPE	DEFINITION	ALLOWABLE TRANSFORMATION	EXAMPLE
Nominal	Completely arbitrary	Any one-to-one	Team jersey numbers
Ordinal	Order preserved	Monotonically increasing/decreasing	Traffic Quality
Interval	Arbitrary units and origin	Positive Linear ($a \cdot x + b$)	Temperature ($^{\circ}\text{C}$ or $^{\circ}\text{F}$)
Ratio	Natural zero	Multiplication by scalar	Temperature ($^{\circ}\text{K}$)
Absolute	No choice of unit or zero	Multiplication by identity	Counting (1,2,etc.)

In decisions involving certainty, three types of functions are often used to define an attribute. These functions are piecewise linear functions, exponential functions [Kirkwood, 1997: pg 62-68], and discrete functions [Clemen, 1996: pg 80]. Kirkwood provides an exponential function and a piecewise linear function written in Microsoft Excel Visual Basic for converting raw scores to value [Kirkwood, 1997: pg 78-81]. Kirkwood also provides detailed implementation methodology for evaluating value models in Microsoft Excel [Kirkwood, 1997: pg 75-81]. This research methodology makes extensive use of Kirkwood's spreadsheet-based technique.

The single dimension value function converts a quantity being measured into value. Value is typically measured between 0 and 1, but can be measured from either 0 to 10 or 0 to 100 depending upon the desires of the decision-maker [Kirkwood, 1997: pg 61]. Whichever scale used, it must be used for all measures within the value model.

Within the context of this research, a straw model of deployable combinations of combat aircraft has been developed as a part of the Air Force Institute of Technology/Air Force Research Laboratory research [Swartz, 1999]. Within this straw model, two basic aircraft have been identified: a bomber, with two potential configurations; B-A and B-B; and a fighter, with three potential configurations; F-A, F-B, and F-C. Certain configurations of the different aircraft can provide higher or lower levels of *absolute*

capability with respect to completing aerospace missions required by the theater commander. Using these combat aircraft in their possible configurations, unique asset sets, containing different quantities of the combat aircraft in their possible configurations can be developed. These unique asset sets can then be analyzed, based upon their *absolute* capabilities and their campaign specific goodness, to determine which asset set best satisfies the theater commander's requirements.

The purpose of the multiple objective value function within this research is to select the best available alternative based upon the values identified. Scoring alternatives is straightforward, but can be time consuming. Each unique deployable combat aircraft set will have a score that falls within the assigned range of each value function. For each evaluation measure, each set of combat aircraft will be given a value from 0 to 1 depending upon the single dimension value function. Some measures within the value hierarchy will actually be constraints. For these measures, the combat aircraft set will either receive a multiple objective score of 1, denoting it passes the constraint, or a multiple objective score of 0, denoting it does not pass the constraint.

The method of *swing weights* is commonly used to assess the weights for the values in a hierarchy, although other methods are available and often applied [Clemens 1996: pg 546-552; Kirkwood, 1997: pg 68-70]. The *swing weight* method is a thought experiment whereby the decision-maker can directly compare individual attributes by imagining (typically) hypothetical outcomes [Clemens 1996: pg 547]. Each tier of values or measures in the value hierarchy is considered individually. It is very important to keep in mind the range of scores for each particular measure; a change in the range of a particular measure can change the rankings of each alternative [Kirkwood, 1997: pg 58-

59]. To determine weights, the decision-maker or the decision-maker's representative is asked to rank the measures from least important to most important. The ranges for each measure are then studied singularly. The measures will be studied by "swinging" the value of the measure from its lowest to its highest value. The measures can then be compared. The decision-maker or representative will be asked to define the amount of "swing" (from lowest to highest value) that measure "A" would need to equal the "swing" of measure "B" from its lowest to highest value. Given this question, the decision-maker or representative should give a value of importance, or weight, between 0 and 1 for measure "A" compared to measure "B" as shown in (1),

$$0.75A=B \quad (1)$$

In this example, the entire range of measure "B" is equal to 75 percent of the entire range of measure "A." This process continues until there is one less equation than the total number of categories. The final equation required is the summation of all measures to 1. At this point, there is a solvable system of equations with an equal number of equations and unknown measures.

After alternatives are scored and weights are assessed for the values, all values are combined into a single multiple objective value equation. The most common method of accomplishing this is to use an additive value function. The additive value multi-objective function is defined as:

$$v(x_n) = \sum_{i=1}^n w_i * v_i(x_i) \quad (2)$$

Where x is the overall evaluation objective, x_i is the raw score of attribute i , v_i is the single dimension value function, w_i is the weight of importance placed on attribute i , and n is the total number of evaluation measures. Keeney, Kirkwood, and Clemen all discuss

the necessary and sufficient conditions for using an additive value function with value hierarchies [Keeney, 1997: pg 132-138; Kirkwood, 1997: pg 238-239; Clemen, 1996: pg 579-580]. Mutual preferential independence of attributes or evaluation measures is required before using an additive value function under conditions of certainty. Both Clemen and Kirkwood provide formal testing procedures for mutual preferential independence [Clemen, 1996: pg 580-582; Kirkwood, 1997: pg 238-239].

Kirkwood recommends that the results be rank ordered after the values (in this research for sets of deployable combat aircraft) have been identified. Among other tools, a graphical representation of each value's contribution in the hierarchy is a useful tool in presenting the importance of individual measures [Kirkwood, 1996: pg 76-81].

Sensitivity analysis on the weights can be performed to determine the weighting levels that will change the alternative rankings and can determine what the changes in policy would be. If alternatives are insensitive to meaningful variation in weights, further research is unnecessary. If measure weightings are sensitive, analysis of the weights can be focused on specific alternatives or groups of alternatives [Kirkwood, 1997: pg 82-85]. Sensitivity analysis is performed by changing the weight of a single evaluation measure, while holding all other weights to the same ratio as the developed case. All weights for an evaluation measure tier must sum to 1. Therefore, weights can often times be varied from 0 to 1. Kirkwood provides specific guidance on the implementation of sensitivity analysis in a Microsoft Excel spreadsheet [Kirkwood, 1997: pg 82-85].

No decision support tool is completed or useful to a decision-maker if it has not first received approval from the decision-makers themselves. Without buy-in from the decision-maker, a decision support tool is useless at best. Across a spectrum of campaign

planning experts, a consensus on the viability of the decision support tool would best serve to validate the model. The following section describes possible methodologies, and the method selected to obtain constructive feedback and a consensus on the developed decision support tool.

IDENTIFYING THE METHODOLOGY TO OBTAIN CONSENSUS OF THE DECISION SUPPORT TOOL

Several methodologies were initially identified to obtain a consensus of the decision support tool from campaign planners. The first method considered was the formal survey, to be sent to campaign planning experts. However, the same considerations that discounted this methodology from being used in the identification of the issues kept this methodology from being used to obtain consensus of the decision support tool. The second method considered involved structured telephone interviews, coupled with e-mail documents sent to the experts to provide a visual medium with which to conduct the interview. This method would take considerable time to administer, and would not allow a compilation of thought between the subject matter experts polled. Also, documentation of the telephone interviews would be difficult to maintain direct quotation of the expert interviewed. The third methodology identified is the Delphi study methodology. For the reasons described in the following section, the Delphi study was implemented to obtain consensus of the developed decision support tool.

DELPHI STUDY TECHNIQUES

The basic notion, theoretical assumptions, and methodological procedures of the Delphi technique originated in the 1950s and 1960s by Dr. Olaf Helmer and Norman Dalkey at the RAND Corporation as a method to obtain long-range forecasts. Since then,

the technique has been used in numerous situations that require creative solutions to a problem [Oxenfeldt, 1978: pg 167]. The technique is based on a structured process for collecting and distilling knowledge from a group of experts by means of a series of questionnaires interspersed with controlled opinion feedback [Adler, 1996: pg 3].

According to Dalkey, the rationale and use of the Delphi Method represents a systematic effort to make the most of what is, admittedly, an unsatisfactory situation, and to try and obtain the relevant intuitive insights of experts and use their informed judgement as systematically as possible [Adler, 1996: pg 4].

The Delphi technique uses controlled feedback to reduce the amount of extraneous material or *noise* that would otherwise inhibit the process [Breaux, 1997: pg 17]. Dalkey defines *noise* as "irrelevant or redundant material that obscures the directly relevant material offered by participants" [Dalkey, 1967: pg 3]. As part of this feedback process, the researcher filters out irrelevant data and summarizes any and all pertinent information obtained from the participants. The summarized information is then returned to the elicitation group in successive iterations in an effort to arrive at a final solution or conclusion [Dalkey, 1968: pg 3-4]. Each group member's justification and reasoning for the answer provided is included in the summarization (with anonymity upheld). This is provided "to simulate the experts into taking into due account considerations they might through inadvertence have neglected, and to give due weight to factors they were inclined to dismiss as unimportant on first thought" [Brown, 1968: pg 3,6].

The Delphi technique has several advantages over other information elicitation techniques. A key advantage is anonymity. In a typical group environment, a single, dominant individual can oftentimes sway individual opinions. Subordinates may also not

want to cause problems with their superiors by bringing up potential problems. The Delphi technique eliminates the effects of a dominant individual because the responses from all participants are anonymous [Brown, 1968: pg 2-3]. Another advantage of the Delphi technique is convenience. Experts within a specific field of study can be contacted and included at virtually any location in the world, as long as they can receive and send communications [Oxenfeldt, 1978: pg 167]. A third advantage offered is the minimization of pressure to conform to the group. A statistical group response is included as part of the summaries provided to the group participants. However, since minority views can be included in the final result, there is no group pressure to compromise [Brown, 1968: pg 6; Dalkey, 1967: pg 3-4]. This removal of group pressure eliminates a major bottleneck in most group dynamics by providing opportunities for a clear delineation of differing views in a non-threatening environment [Adler, 1996: pg 7].

In almost every application of the Delphi Method, two distinct phases can be identified. The first is defined as the *exploration phase*, whereby one or two series of questionnaires are used to fully explore and elicit additional information regarding the subject in question. The key to this phase is ensuring all members of the expert group understand the aim of the Delphi study, understand the terminology and methods used, and are actually competent and confident in the material under study. Expert group members do not need to be experts in Delphi techniques to accomplish the tasks required.

The second phase, or *evaluation phase*, usually involves the process of assessing and gathering the expert group's views on various ways of addressing the issues of the study. It is important to note that the views obtained from the expert group may not necessarily form a consensus; disagreements and differing views on the subject in

questions may be just as useful to a better understanding of the issues surrounding the study. The evaluation phase is generally conducted within one or two series of questionnaires following the evaluation phase. Group experts are usually asked to rank items and to establish preliminary priorities among items of discussion. This can help to prioritize items of agreement and disagreement among group experts as well as identify issues requiring further explanation.

The determination of appropriate experts and group size are also important preliminary requirements to the Delphi technique. Experiments carried out in the 1950s and 1960s show that there is an improvement in the quality of the group outcome with increasing group size, to a certain threshold [Adler, 1996: pg 14]. Above this threshold, including additional experts provides only a marginal benefit to the distillation process.

Expertise is usually a key requirement in selecting members for a Delphi panel. The purpose of using experts specific to the aim of the study is to elicit responses and solutions to the study that are more meaningful than if just anyone participates in the study. Selection of these experts is generally not conducted as a matter of personal preference; rather, it must follow explicit criteria depending upon the aims and context within which the Delphi process is to be carried out [Alder, 1996: pg 14]. Potential group members must have knowledge and practical engagement with the issues under investigation. Potential group members must also have the capacity and willingness to contribute to the study conducted. As with any writing intensive activity, potential group members must be able to clearly express themselves through written communication. Academic qualifications should not preclude a potential group member from the study, unless the aim of the study specifically requires such requirements.

To increase the chances that a study group will be creative and synergistic in thinking, the group should be united in their effort to accomplish their task. One simple method to help accomplish this synergy and creativeness is to use a *straw model*. A straw model is a conceptual model of the group's task. It defines the parameters of the task and presents a perspective on how the task can be accomplished [Adler, 1996: pg 43]. This model need not be complete, and it may include inaccuracies or omissions in information. The straw model helps to make a group aware of the areas where they must concentrate their efforts and to provide a target for a group to accomplish.

Why do campaign planners need a decision support tool to assist them in identifying and managing campaign-specific issues? This section discusses the current state of Air Force operations as implemented through the Air Expeditionary Force concept. The current concept of operations shows the need for campaign planners to obtain a decision support tool that will improve the efficiency and effectiveness of campaign planning, leading to the deployment of the right assets to meet the mission.

CURRENT STATE OF AIR FORCE OPERATIONS

"Global Engagement: A Vision for the 21st Century Air Force" is the result of an 18-month long-range planning effort [Global Engagement WWW paper]. Since November of 1996, Global Engagement has succeeded "Global Reach-Global Power" as our air force's strategic direction into the next century, providing the vision behind how our air forces will fight.

During the Cold War, the well-manned stateside Air Force concentrated on generating and launching aircraft from the continental United States (CONUS) to reinforce the significant number of forces well established in the European or Pacific theaters. As a result of the end of the Cold War, the need for significant forward presence to deter Communist forces diminished. As seen during every other time of relative peace, the United States made dramatic reductions in its number of armed forces. Most of these forces came from overseas locations, significantly drawing back our global presence. However, as our nation's forces were drawing down and back, Iraqi aggression made it clear that we still must be able to strike quickly and with decisive force to any location. According to Global Engagement, CONUS-based forces will become the primary means for this expedient power projection and crisis response.

The new vision of our Air Force is built upon six core-competencies: air and space superiority, global attack, rapid global mobility, precision engagement, information superiority, and agile combat support. Air and space superiority not only brings our forces freedom from attack, but allows us to dominate the other person's airspace. This dominance provides further freedom to attack targets across enemy territory while denying sanctuary to enemy forces. If we have air and space superiority, our forces will then naturally want to be able to precisely engage the enemy. Precision engagement goes beyond precision weapons to include precision airlift, aerial resupply, and the precision that comes from decisively attacking an adversary's command and control system at the right place and at the right time. Global attack, rapid global mobility, and agile combat support go hand-in-hand. The Air Force must be able to hit targets while operating from CONUS bases, but must also be able to provide expeditious deployment and sustainment

around the world. Information superiority entails being able to both defend our information systems and attack the enemy's.

AEF/AEG CONCEPT

The key to US global dominance is the ability to project power quickly any polace in the world. The Air Expeditionary Force (AEF) and Air Expeditionary Group (AEG) concepts have become the primary Air Force tools for realizing the Global Engagement vision of CONUS-based crisis response and action. According the Secretary of Defense William S. Cohen, the primary AEF mission is to provide regional commanders in chief (CINCs) and Joint force commanders with vital air and space forces. These forces can carry out wide ranging airpower options, meeting specific theater needs across the full spectrum of military response options [Cohen, 1998]. The AEF/AEG concept fits nicely within the core competencies of the Air Force. According to Brigadier General William R. Looney III, the AEF makes the final transition from a force founded on the strategy of forward-based presence to one built on the vision of global engagement [Looney, 1996: 5]. An AEF is an airpower package that usually consists of 30 to 40 aircraft. This package is developed to provide theater commanders with rapid, responsive, and reliable airpower capabilities and options that meet specific theater needs [Looney, 1996: 6]. The goal of the AEF is to launch combat sorties in-theater 48 hours after an 'execute order' is issued and then sustain combat airpower for the duration of the conflict or crisis. A typical AEF package comprises 30 aircraft; 12 air superiority, 12 strike, and six Suppression of Enemy Air Defense (SEAD) fighter aircraft [Looney, 1996: 6]. This package was later increased to 36 aircraft by adding an additional six SEAD fighter aircraft [Godfrey, 1998: 1]. However, due to the variable and unforeseeable nature of

enemy actions and theater requirements, AEF packages can be tailored to meet specific needs and threats. Tanker, Cargo, and Bomber assets can be added as needed or required. Bomber assets can be provided from either CONUS based locations, or deployed to a forward location, near the threat, that is capable of taking these aircraft.

The Chief of Staff of the Air Force, General Michael Ryan, set a target of 1 Oct 99 to initiate the AEF concept across the Air Force. Currently, two of the 10 AEF force packages sit on what is similar to alert status, rotating every 90 days. These two AEFs will then stand-down to a training and recovery status for a period of 12 months, while other AEFs stand alert. The two AEFs will then stand back up on alert, completing the 15-month cycle.

If an AEF is called to deploy, the tasked units plan for a seven-day operation [Katzaman, 1998: 1]. During this operation, the AEF will provide a quick, sustained, initial strike capability, designed to halt (or at least delay) the advance of an enemy [Godfrey, 1998: 2]. As the AEF is engaging the threat, CONUS based forces are preparing to complement or reinforce the AEF forces.

The question of the proper mix of required fighter and bomber aircraft is of critical importance to the theater commander. Under the example of a typical AEF package, the threat may be able to be satisfied with an enhanced squadron of F-16s. Another threat however may require a significant presence of bomber aircraft. In determining which aircraft should be called upon to meet the threat, the aircraft selected must be able to meet the required missions. Thus, it is the campaign planner's responsibility to meet the needs of the theater commander with the best possible set of combat aircraft for the least cost possible. The selection of aircraft must be based on not

only the absolute capabilities of the aircraft, but the campaign-specific considerations that may limit the capabilities of those aircraft.

The next section discusses current campaign planning operations. This research focuses on developing a decision support tool to aid campaign planners in selecting the best value set of combat aircraft to deploy in response to a theater crisis. To develop a tool that improves current campaign planning operations, the current state of campaign planning must be discussed.

PLANNING FOR WAR

At both national and departmental levels, various processes and systems have been developed to handle the complex problems of setting strategic direction, determining national military policy, requesting resources to execute that policy, and translating the funded military capability into military operations. The joint planning process is one link in a long and complex chain. The purpose of joint operation planning is to use the military element of national power effectively to protect U.S. interests. Joint planning is a process, a systematic series of actions or procedures, used by a commander to determine the best method of accomplishing assigned tasks [JSOG, 1997: para 500].

The Joint Operation Planning and Execution System (JOPES) is the integrated, conventional command and control system designed to satisfy the information needs of senior decision-makers in conducting joint planning and operations. The Joint Planning and Execution Community (JPEC) use JOPES to conduct joint planning during peace and crisis. Joint operation planning must be coordinated through all levels of the national structure for joint planning and execution, including the National Command Authority and the JPEC. The focus of JOPES is centered on the combatant commanders, who use it to determine the best method of accomplishing desired or assigned tasks and direct the actions necessary to accomplish the mission. During Crisis Action Planning (CAP), JOPES facilitates the rapid development of effective options and operation orders through the adaptation of approved operation plans. JOPES is also an effective management tool for the execution of operations across the spectrum of mobilization, deployment, employment, sustainment, and redeployment [JSOG, 1997: para 506].

JOPES implements policies, procedures, personnel, and facilities by interfacing with automated data processing systems currently available on the Global Command and Control System. JOPES supports senior-level decision-making through the staffs at the NCA level and throughout the JPEC.

JOPES planning is based on both requirements and capabilities. Military planners use forces and resources identified in orders from the Joint Chiefs of Staff, Service documents, and approved operations plans and orders. JOPES identifies the required level of forces and resources to accomplish the mission, and then compares them to actual forces and resources available based upon current availability and other commitments. If adequate forces and resources cannot be provided to the required level, planners conduct a risk analysis, adjusting the Commander-in-Chief's (CINC's) concept of operations to an acceptable level of risk.

Four Chairman of the Joint Chiefs of Staff Manuals (CJCSM) describe the operation and use of JOPES. Two of these manuals provide information relevant to this research. CJCSM 3122.01 (Joint Pub 5-03.1), *Joint Operation Planning and Execution System Volume I (Planning Policies and Procedures)*, unclassified, describes the policies and procedures governing the joint conventional deliberate and crisis action planning processes under JOPES. CJCSM 3122.03, *Joint Operation Planning and Execution System Volume II (Planning Formats and Guidance)*, unclassified, examines operation plan formats and gives guidance for joint conventional planning and execution under JOPES. Joint Publication 3-56.1, *Command and Control of Joint Operations*, unclassified, and Joint Publication 5-00, *Doctrine for Planning Joint Operations*, unclassified, provide crisis action planning guidance from a joint perspective.

The functional structuring of joint operation plans in JOPES annexes and appendices is not specifically directed to the unique organizational structure of each of the military services. Because of this, the Air Force requires additional functional annexes to those prescribed in JOPES. Air Force Manual 10-401 Volume I, *Operation Plan and Concept Plan Development and Implementation*, unclassified, and Air Force Manual 10-401 Volume II, *Planning Formats and Guidance*, unclassified, provides JOPES focused planning information from a more specific USAF perspective. It is interesting to note that USAF planning guidance, while 'air-centric,' does focus on the need to strategically plan from a joint perspective. Air Force Doctrine Document 2, *Organization and Employment of Aerospace Power*, as well as information from Air University's Joint Doctrine Air Campaign and Contingency Wartime Planning Courses, provide additional information on planning requirements and issues specific to the Air Force.

Joint Publication 5-03.1, *Joint Operation Planning and Execution System Vol I (Planning Policies and Procedures)*, provides information that commanders should address when planning the deployment of forces in response to a crisis situation. Crisis situations are generally classified as small, less than major-theater-war scale operation that may require force as all other political and diplomatic options are failing. A recent example of a crisis situation was Kosovo in the Spring 1999, where combat aircraft were required to deploy, conduct, and sustain combat operations.

The review of joint publication 5-03.1, particularly Chapters 3, 5, and Annexes C, D, and P, was useful in the development of the initial value hierarchy by this researcher. In Annex C, the Chairman of the Joint Chiefs of Staff sends a *warning order* to

operational forces that may be required to deploy. The *warning order* will provide information on the type of missions required, political considerations present in and around the enemy location, enemy capabilities and current operation, and host-nation considerations. Annex D, the *Commander's Estimate*, provides the theater commander with the opportunity to add additional information that may or may not be present in the warning order. Annex P provides further information on the development of the *Commander's Estimate*. This information may include the required operational capabilities needed to engage the crisis, staging base considerations, and more detailed enemy capability information. The theater commander normally will provide his staff, subordinate commanders, and supporting commanders with pertinent initial planning guidance to permit work to begin on developing the theater commander's strategic concept [JPUB 5,03-1, 1993: pg 269]. The staffs use this guidance to begin developing the Staff Estimates that will be used to form the *Commander's Estimate*. Typical data provided in preliminary guidance such as the *Commander's Estimate* includes characteristics of the area of operations, enemy capabilities, the mission statement, assumptions, special weapons, political and psychological considerations, tentative courses of action (COAs), and a proposed planning schedule.

Air Force Doctrine Document 2, *Organization and Employment of Aerospace Power*, provides complementary guidance to JPub 5-03.1 on deliberate and crisis-action planning. Campaign plans allow theater commanders to set operational tempo, direct the conduct of battles, envision objectives, develop concepts, and coordinate logistics to achieve victory. Planning combat operations revolve around precise communication of commander's intent and a shared, clear understanding of the appropriate operational

concepts at each level of command. The Joint Air and Space Operations Plan (JASOP) and supporting plans, developed in coordination with the Joint Air Component Commander and Joint Forces Commander (JFC), state how the air commander conducts theater air and space operations. This is the heart of what is colloquially called 'the air campaign.' The JASOP is developed during the concept development and plan development phases of deliberate planning, as the foundation of an OPLAN or CONPLAN; or during the execution planning phase of crisis action planning, in concert with overall theater campaign planning. Developing the JASOP involves a five-stage planning process, with each stage producing a product. While the stages are presented in sequential order, work on the various stages can be either concurrent or sequential. The first stage of JASOP development is directly relevant to this research.

Operational environment research focuses on gaining a comprehensive understanding of the entire theater of operations, the adversary, and friendly forces available to accomplish the JFC's objectives. Issues that must be considered during this stage include available forces, command relationships (national and multinational), threat and force protection requirements, rules of engagement, applicable treaties and agreements, base-use rights, and overflight rights. Available support from allies and the degree of political and social stability in the region are also important to study. Additionally, appropriate logistics information is acquired concerning what is available in theater and what is provided through existing ports, depots, war reserve materiel, and host-nation support. Finally, a detailed intelligence picture is developed that includes indications and warning, current intelligence, general military intelligence, target

intelligence, and a complete analysis of enemy, neutral, and friendly forces and potential courses of action.

Following the guidance of JPub 5-03.1 and Air Force Doctrine Document 2, the specific types of contextual issues examined during the crisis action planning process are incorporated into an initial hierarchy of issues. This developed hierarchy of issues, presented as Figure 1, is the foundation upon which this research is conducted.

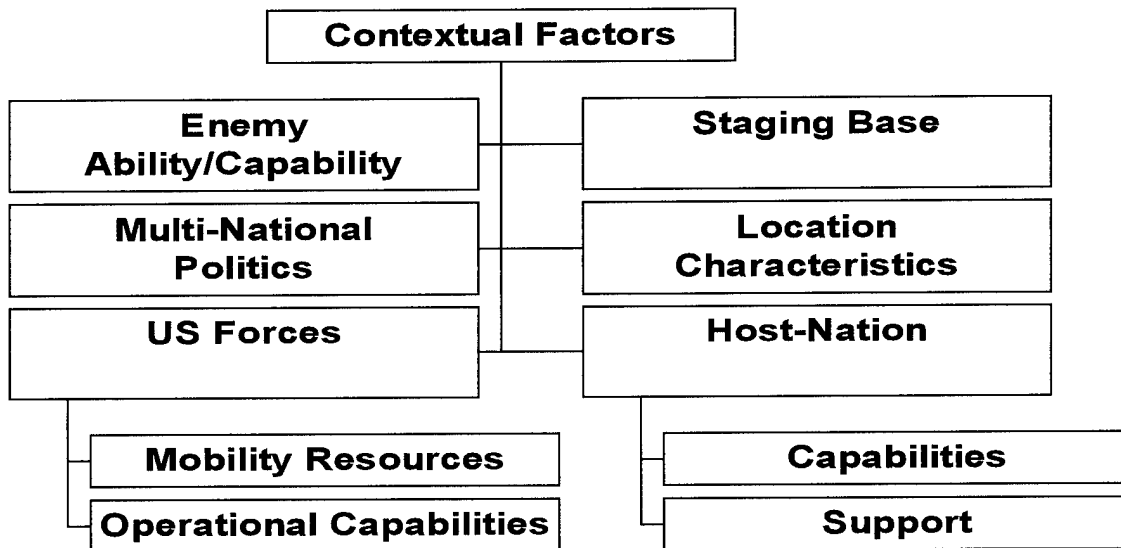


FIGURE 1: Initial value hierarchy.

Six top-level issues are identified, each of which is discussed in both JPub 5-03.1 [JPub5-03.1, 1994; pg P-1 to P-6-5] and AFDD 2 [AFDD 2, 1998; pg 76]. The *US Forces* and *Host-Nation* issues are expanded to include sub-issues relevant to the capability of our forces to conduct combat operations in the theater.

SUMMARY

This chapter reviews current Air Force and Joint documentation on planning factors considered when selecting combat aircraft to deploy in response to a crisis. Threats can vary significantly; therefore, theater commanders must be able to tailor their response to the current threat. The methodological tools and techniques appropriate for this research are also reviewed. Interviewing techniques based upon the Cognitive Task Analysis theory, a tool to understand the cognitive requirements of individuals involved with a task or decision, are presented and explored. Value Focused Thinking, a methodology to assist decision-makers in making better decisions, are also reviewed. The Delphi Study technique, a tool for eliciting group conformity on a specific topic or subject, is presented and discussed. The next chapter describes the methodology behind the deployment planning factor elicitation interviews, the development of the Value Focused Thinking decision support tool, and the Delphi study used to confirm the decision support tool and determine weights for the value analysis.

III. METHODOLOGY

The methodology for this research consists of three phases, as shown in Table 2 below.

TABLE 2: RESEARCH METHODOLOGY PHASES	
Phase I	Cognitive Task Analysis Interviews
Phase II	Value-Focused Thinking Decision Support Tool Development
Phase III	Delphi Study Decision Support Tool Confirmation

Phase I of this research, and the literature review on campaign planning, are conducted to answer research question 1, *What factors other than absolute aircraft capabilities should campaign planners consider when selecting a specific set of combat aircraft to counter a theater threat?* Research questions 2 and 3, *How are these factors qualified,* and *What relationships link these factors to each other,* respectively, are answered by Phase II of this research. Phase III focuses on answering research question 4, *Based on a Southwest Asia scenario, what is the relative importance of each factor with respect to the others?*

Phase I applies a cognitive task analysis (CTA) to experts in Air Force combat deployment planning, in order to develop a comprehensive list of planning considerations or decision points that campaign planners must consider when deploying combat aircraft. Phase II takes the information gleaned from the Phase I CTA and develops the decision points into a quantitative, value focused thinking (VFT) decision support tool. This phase is conducted by interviewing campaign planners and staffers at Air Force Central Command. Phase III uses a Delphi study to obtain agreement from the individuals studied on the factors defined and develops weights of importance, relative to each other,

within the VFT decision support tool. The development and operation of these three Phases are presented within this chapter.

PHASE I – CTA STUDY

OBJECTIVES OF CTA

The objective of the Cognitive Task Analysis is to elicit campaign-specific planning considerations or factors, not tied to the absolute capabilities of individual USAF combat aircraft, that campaign planners and theater commanders must take into account when groups of combat aircraft are selected to deploy. The CTA serves to confirm and expand the Base Value Hierarchy developed through the literature review of Joint and Air Force campaign planning publications and doctrine. This expanded value hierarchy provides the basis for the development of a campaign-specific, combat aircraft selection, decision support tool.

OBJECTIVES OF COGNITIVE DECISION MAKING USE

The Cognitive Decision-Making (CDM) analysis, discussed in Chapter II, is used to elicit campaign-specific issues from subject matter experts. These issues can be described as points in the campaign planning process where critical decisions, decisions that a novice would have sufficient difficulty overcoming, may be required. The presence and severity of these issues may hamper the selection of a specific set of combat aircraft.

JOB DESCRIPTION, PRIMARY TASKS, AND TASKS ANALYZED

When campaign planners perform their crisis action planning function, they are often constrained by time and operate under immense pressure. Crisis action planning

requires a significant level of knowledge and understanding of the planning and deployment process. The purpose of the CTA is to study this cognitive portion of the planning process in an effort to provide campaign planners with a tool that identifies possible issues and constraints that may plague a deployment plan. This tool can help campaign planners to maintain awareness of these issues and constraints, whereas they may otherwise go unnoticed during the development of the plan due to time and operational constraints.

PARTICIPANT SELECTION

Twenty Air Force officers knowledgeable in deployment operations, through both experience and training, were interviewed. These subject matter experts (SMEs) were selected from Aerospace Operations offices of Air Combat Command and Air Staff, campaign planning instructors from Air University, and campaign planners from Air Force Central Command. These individuals hold the rank of major through colonel; all have a presumed level of experience in deployments and planning.

MATERIALS

A Bullet Background Paper (BBP) [Tongue and Quill, 1995; pg 137] is developed as a pre-talker for the interview. This paper is given to each interviewee at the start of the interview and is briefly discussed to acquaint the interviewee to the subject. The BBP is presented as Appendix A.

The BBP is developed following the CDM interview method described by Klein et al. [Klein et al., 1997: Pg 2]. Klein discusses how CDM interviews need to focus in on a specific task or set of tasks. The course of the interview should move from a general

overview of the task or set of tasks to specific details on the cognitive requirements of the individual task or tasks. The BBP is developed in order to provide the interviewee with a brief description of the basis for this research, an overview of how the interview is conducted, the objectives of the interview, based upon Klein et al. methodology, and to provide contact information for the research. The description section discusses the evolution of the Expeditionary Air Force concept and how this research came to light. The interview overview section provides the interviewee with a focus for the questions that are asked during the interview. A review of this section assists the interview process by focusing the interviewee on the areas of knowledge and expertise that are relevant to the interview. The final *contact* section of the BBP provides the interviewee with information on how to contact the researcher if the interviewee has any additional information or questions regarding the interview or the research in general.

A narrative for the interview is developed to assist the interviewer in conducting the interview. The narrative is developed in the image of Klein et al. Methodology, and provides the interviewer with a summary of the important points to hit during the interview as well as a short list of probes to use to elicit knowledge and understanding of the decision points. The interview narrative is presented as Appendix B. The narrative is developed to assist the interviewer in maintaining the specific focus of the interview goals, which is to identify the non-technically driven issues that campaign planners have historically considered when selecting combat aircraft to respond to a theater crisis.

A base value hierarchy, used during the interview, is developed using the initial value hierarchy presented in Figure 1 of Chapter 1 of this document and through discussions during OPER 649, *Advanced Decision Analysis*, at the Air Force Institute of

Technology (AFIT). This base value hierarchy is presented as Figure 2. The objective of the OPER 649 class is to develop the Value Focused Thinking Decision Support tool, which is discussed in Phase II, *Value Focused Thinking Decision Support Tool*. LTC Jack Kloeber, USA, conducts the course. During this course, several evolutions of the initial Campaign-specific Issue value hierarchy led to the development of the CTA study value hierarchy shown in Figure 2.

Comparing the initial value hierarchy and the CTA study value hierarchy, many obvious differences are noted. First, the CTA study value hierarchy is developed to better represent the motivation behind the value hierarchy; many separate issues must be considered in order to determine the aircraft asset set that provides the best value, or worth, to the theater commander. *Host-Nation* and *Multi-National Politics*, given top-level values in Figure 1, have been incorporated together in Figure 2.

Campaign Specific Issue Hierarchy

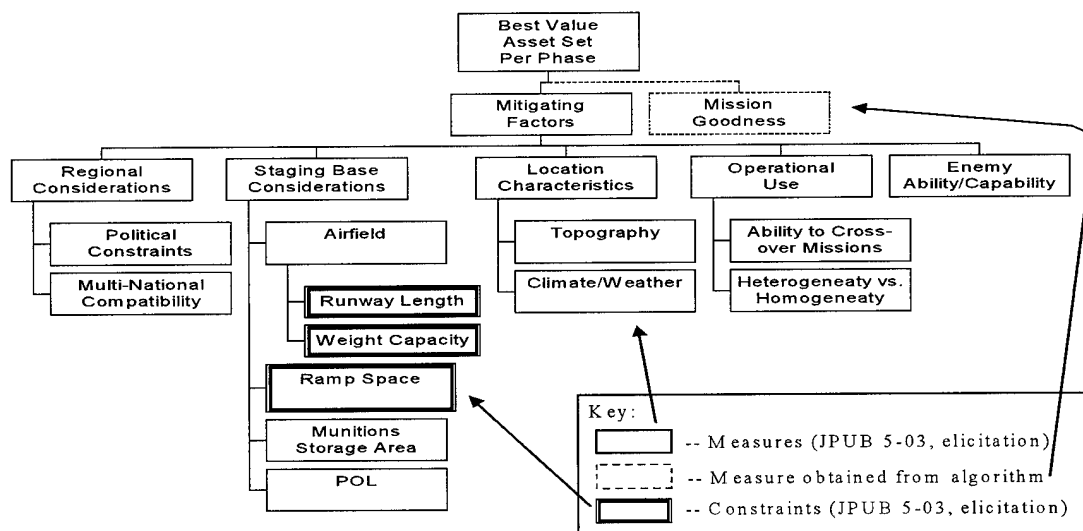


FIGURE 2: CTA study base value hierarchy.

The *Host-Nation* and *Multi-National Politics* issues are combined because it is believed that they are similar in their focus on the location of the theater. The *Staging Base* value is expanded based upon the civil engineering experience of the researcher, and through discussions in the OPER 649 course. At this point, the *Airfield* issues: *Runway Length* and *Weight capacity*, as well as *Ramp Space*, are identified as constraints. These issues may prohibit a particular set of assets from bedding down at a pre-determined staging base if the staging base cannot support the physical characteristics of the aircraft in the asset set. *Munitions Storage Area (MSA)* and *Petroleum, Oils, and Lubricants (POL)* issues are added based upon their importance to operational requirements at the pre-determined staging base. Depending upon the capabilities of the staging base with respect to *MSA* and *POL* issues, the operational capability of the combat aircraft within a unique asset set may be hampered. Location characteristics are also expanded to provide a better description of the types of issues studied. Through OPER 649 discussions, as well as discussions with Major Alan Johnson, USAF, and Major Steve Swartz, USAF, both assistant professors at AFIT, it is determined that both *topography* and weather or *climate* characteristics at the location of the pre-determined staging base may be important issues. Based upon the analysis of the initial value hierarchy, the *US Forces* factor is removed from the CTA study hierarchy. The *Operational Capabilities* factor is a direct analysis of the absolute capabilities of the combat aircraft, which is outside the scope of this research. Therefore, this factor is re-located to the top tier values on the CTA study hierarchy, adjacent to the Mitigating Factors. *Mission Goodness* is defined under this study as the absolute capabilities of each individual type of fighter and bomber aircraft to complete specific aerospace missions defined by both Air Force Manual 1-1

and Air Force Doctrine Document 2-1. *Mobility resources*, important to the capability of USAF forces to complete specific aerospace missions, are also outside the scope of this research. Therefore, this issue is removed from the CTA study hierarchy. *Mobility resources* will be specifically studied in the larger scope of the AFIT and Defense Advanced Research Projects Agency research with the Advanced Logistics Project.

During the CTA interviews, the value hierarchy is used only to motivate the interview if the interviewer feels that the interview is not progressing satisfactorily. Poor interview progress is of primary concern if the interviewee either does not understand the issues important to the research, the interviewee can not think of any issues early in the interview, or the interviewee is not responsive to the questions as they are presented. The value hierarchy that is used for these interviews is presented as Figure 2.

CTA PROCEDURES

The interview is developed using the "Interviewer's Manual" [Interviewer's Manual: pg 15] and CDM interview technique [Klein et al., 1997: pg 2]. Probes are used to elicit insightful information from the subject matter experts (SMEs). The use of probes in unstructured interviews serves two major functions. First, probes help to motivate the interviewee to communicate more fully, enabling the interviewee to enlarge upon, clarify, or explain the reasons behind what is said. Secondly, probes help the interviewee to focus on the specific content of the interview so that irrelevant and unnecessary information can be avoided. The interviewer's most important concern is to ensure that probes are used without introducing bias into the interviewee's discussion of the issues. The Interviewer's Manual [Interviewer's Manual: pg 15-18] and numerous articles on CTA and CDM discussed in this paper provide possible probes useful in CDM

analyses. Probes, as detailed and presented by Klein et al., [Militello, 1998: pg 1622] are used during the CDM interviews. An interview script, discussed earlier, is used to assist the interviewer during the interview and to ensure the interview itself was kept on track with the research goals.

The interviews follow a modified CDM methodology. The interviewees are first presented with a Southwest Asia Theater, Air Expeditionary Force deployment scenario. The interviewees are then asked to speak to their knowledge and understanding about deploying combat aircraft under this scenario. This allows the interviewee to become acclimated to the topic of discussion and to the level of operational experience and knowledge polled. During this portion of the interview, the interviewee is allowed to relate the problem to situations that he or she has experienced first-hand. Comments based upon hearsay are ignored. Using the modified CDM methodology, the interviewer should try to keep the interviewee motivated to continue his or her discourse throughout the interview. Before individual interviews are concluded, the interviewer should attempt to obtain clarification on points that may have only been previously touched on, confirm or deny unclear comments, and elicit any further comments.

PHASE II – VALUE FOCUSED THINKING STUDY

OBJECTIVES

The Value Focused Thinking (VFT) study holds two purposes. The first is to validate and verify the information, obtained through the interviews held as a part of the Cognitive Task Analysis (CTA) study, with current Southwest Asia (SWA) campaign planners. The second purpose is to define a quantifiable range of values for, or if not

quantifiable identify as a constraint, each of the campaign-specific issues. Through the two components of this phase, a more complete hierarchy of values can be developed. This value hierarchy is incorporated into a spreadsheet-based VFT decision support tool.

PARTICIPANT SELECTION

Current campaign planners from Headquarters, USAF Central Command (CENTAF) are participating in the construction of the decision support tool. As the research is focusing on a SWA contingency deployment, it is believed that CENTAF planners have the required knowledge and experience to act as the decision-maker representatives.

MATERIALS USED

A dictionary of campaign-specific issues assists the VFT study. This dictionary presented as Appendix C is important to maintaining consistency in the description of the campaign-specific issues and as to how these issues are measured. These definitions are adjusted if, during the VFT study, the interviewees feel that different definitions better represent the views and requirements of the theater commander.

An example graphical representation of the measurement of the campaign-specific issues is presented as Figure 3. A single, blank graph is used for each campaign-specific issue prior to the interview. For each issue, X and Y-axes are presented. The X-axis represents the measurement upon which a specific aircraft asset or asset set is measured. The Y-axis represents the transformed value or worth to the commander. For each issue, regardless of the type and range of measurement, the Y-axis represents value, ranging from 0 to 1. The individual issue X-axes are quantified on how the individual

issues can be measured. The graphical representation shown in Figure 3 presents how the decision-maker views the transformation of measurement to value. Note that the presented linear graph is just an example.

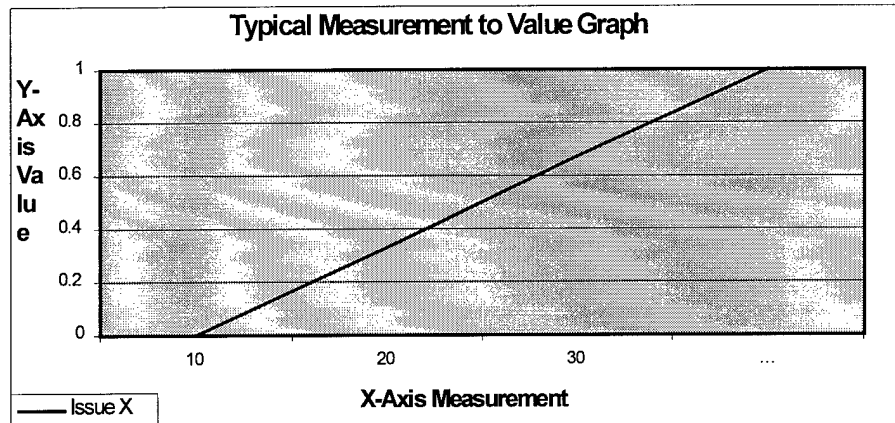


FIGURE 3: Typical measurement to value graph

Discussions during OPER 649, and with LTC Kloeber, Major Johnson, Major Swartz and current AFIT graduate students aided in developing these measurements. The individual campaign-specific issue graphs are presented as Appendix D. Since operational capability is the main focus behind these issues, degradation to mission capability is used as the measurement for many of the issues.

These blank graphs, presented in Appendix D, are individually printed onto paper and placed in a clear plastic cover. The plastic-protected graphs are placed into a three-ring binder. This medium facilitates the smooth transition between graph presentations, and allows the decision-maker representative to re-think functions previously developed without wasting time.

To quickly familiarize the study participants to VFT methodology, a short example of buying a car was developed and described. This example is presented as

Appendix E. This example is used to provide a basic level of understanding to the CENTAF decision-makers on VFT methods.

PROCEDURES

A group meeting is arranged with campaign planners from CENTAF. At this meeting, the campaign planners are the decision-makers in the development of the campaign-specific issue measurements. A brief description of the purpose of this research and a background of VFT is presented. The updated value hierarchy is then presented to facilitate feedback and agreement upon the value hierarchy as it has been developed to this point. Once acceptance is achieved or the correct changes are made, the VFT interview can begin.

The purpose of the VFT interview is to elicit a range of measurement for each of the campaign-specific issue measures in the value hierarchy. Campaign-specific issue constraints are not be discussed at this interview, due to the fact that these issues have been developed as either "yes" or "no" values. Each campaign-specific issue measure is presented individually, allowing the decision-makers to focus on how each issue is measured specifically. A pre-determined range of measurement for each issue is first presented, as shown as the X-axes in the graphs shown in Appendix D. This provides a starting point for discussion with the decision-makers, allowing them to change or alter the measurement range as needed. Once the X-axis measurement was confirmed, the measurement scores that would result in the lowest and highest values (Y-axis) respectively were presented to the interviewee. These points were marked on the plastic protective sheet using a Vis-à-vis marker. The interviewee was then asked at what score of measurement would the campaign specific issue begin to substantially lose value (i.e.

at what point along the X-axis would the value of the campaign specific issue drop from the high value of 1.0). After marking this point on the plastic-protected graph, the interviewee was then asked to identify the point at which the campaign specific issue begins to substantially increase in value, from the low value of 0.0. This point was also identified on the graph using the Vis-à-vis marker. The interviewee was then asked to “connect the dots”, visually describing how the scoring of the individual campaign specific issue would translate to value to the commander. After a monotonically increasing or decreasing function was satisfactorily drawn on the graph, the interviewer was asked if he was satisfied with the function. The graphical response shown in figure 3 is an example of what the interviewee may identify as the function, but exponential or step functions may also occur. This process was continued until a function was identified for each of the campaign specific issues.

Once ranges of measurement have been obtained, value functions are elicited via classical VFT interview techniques, techniques of which have been developed by Keeney and modified by Kirkwood [Kirkwood, 1997; pg 300-320]. The final product of this VFT interview is a range of measure and single dimension value function for each measurable campaign-specific issue presented in the value hierarchy.

PHASE III – DELPHI STUDY

OBJECTIVES OF DELPHI STUDY

The purpose of this Delphi study is to elicit relative weights of the individual campaign specific issues identified. Campaign planning SMEs contacted during the CTA and VFT interviews are asked to participate in the Delphi study. The 25 USAF officers

that comprise the DELPHI study pool are listed as Appendix J. Two rounds of questionnaires are conducted, with two questionnaires per round.

Delphi Study Round One (questionnaires #1 and #2):

There are three purposes to the first round of questionnaires:

- 1) Reacquaint the SMEs to the purpose and aim of the Delphi study and the overall research focus
- 2) Present and confirm the updated value hierarchy, shown as Figure 4
- 3) Provide a first attempt at converging to a consensus the relative ranking of individual campaign specific issues

Delphi Study Round Two (questionnaires #3 and #4):

There are two purposes to the second round of questionnaires:

- 1) Continue discussion on the validity, content, and organization of the value hierarchy, making changes warranted from first round of Delphi study
- 2) Determine the individual weighting of each Campaign Specific Issue as they fit into the value hierarchy

PARTICIPANT SELECTION

Participants from the CTA interviews and VFT decision support tool construction are invited to participate in the study. Each of these individuals has a general understanding of the goal of the research and has expertise in campaign planning and deployment. It is therefore believed that the SMEs can provide useful feedback and continued guidance on the value hierarchy, decision support tool, and decision point weightings.

DELPHI STUDY DESIGN

The purpose of the Delphi study is to elicit an agreement, between the SMEs used in the CTA analysis, on the VFT decision support tool. The Delphi study is also used to elicit weights for each of the campaign-specific issues within the value hierarchy. This study is being conducted via electronic mail. Phone interviews are conducted only if specifically requested by the individual SME.

Questionnaire #1 in the Delphi study provides the SMEs an introduction to the Delphi technique, as well as a review of the research focus. The questions asked of the experts within questionnaire #1 are dedicated to the confirmation of the value hierarchy produced through interviews with the SMEs themselves, as well as a confirmation of the decision support tool as it was developed through the aid of CENTAF campaign planners. Questionnaire #1 also asks the SMEs to rank order the campaign-specific issues based upon their ranges of measurement. This questionnaire is presented as Appendix F. Both questionnaire #1 and #2 are electronically mailed (e-mailed) to all SME participants in a group mailing. The answers provided from questionnaire #1 are compiled and presented in questionnaire #2. The Delphi study takes several series of questionnaires to come to an actual agreement on the questions asked. Each successive questionnaire also provides a presentation of the comments made on the previous questionnaire.

Questionnaires #3 and #4, comprising the second round of the Delphi study, ask the participants to identify a numerical weight for each of the campaign-specific issues, relative to and consistent with the rank ordering they determined in the first round of questionnaires. The second round of the Delphi Study seeks to determine the relative weightings of the individual campaign specific issues as they related to each other in the

value hierarchy. It should be carefully noted that these weightings have been focused on an Air Expeditionary Force (AEF) deployment to the Southwest Asian (SWA) Theater, in which the *primary* purpose of the deployment is to conduct crisis-action response combat actions. It is hypothesized that a deployment to a different theater for a different purpose would lead to a different set of weightings on the campaign specific issues. It should also be noted that Campaign Specific Constraints are not discussed in this questionnaire, although they were ranked for level of importance in the previous round of the Delphi study. In determining weights, constraints do not apply because they either completely impact the alternative asset set, or they do not at all impact the alternative asset set. As constraints are either *go* or *no-go*, weightings do not apply.

The process of eliciting the relative weights is made easier through the ranking of the campaign specific issues during the first round of the Delphi study. This phase of the study is conducted in two separate but equivalent methods. The first method is to develop questionnaire #3 for e-mail delivery and response. The second method of this phase of the study is to interview study group members in person. Questionnaire #4 in the Delphi study confirms the individual campaign specific issue weights and concludes the study.

Questionnaire #3 has one question. This question focuses on the relative weighting of the campaign specific issues as they relate to each other. Based upon the rankings provided from the previous two questionnaires, the highest-ranking sub-issue within each parent issue is compared to the other sub-issues within that parent issue. By comparing these highest-ranking sub-issues, the relative weightings of the parent issues

can be obtained with respect to each other. To compare the sub-issues, the following question is asked for each pair of sub-issues.

Please state how many times more important the swing from best score to worst score for the issue in Column 'A' is than the swing from best score to worst score for the issue in Column 'B'.

The question above compares the entire range of Issue Y measurement to the entire range of Issue X measurement. This comparison of range can be easily transferred into a loss of value, as the range of measurement for each issue translates to a total value of 1. This question therefore asks the survey respondent to quantify the difference in value for each two compared issues. For example, if the issue in Column 'A' were described to be twice (2x) the importance than the issue in Column 'B,' then the relative weight of the issue in Column 'A' is twice (2x) the relative weight of the issue in Column 'B'. The same analysis holds true for the relative weighting of parent-issues with respect to each other. Questionnaire #3 is presented as Appendix G.

Delphi study pool members from Headquarters USAF Air Staff (HQ/USAF), Air Combat Command, and USAF Headquarters Central Command (CENTAF) are interviewed personally to elicit their knowledge and opinions on the relative weightings between the campaign specific issues. Interview participants are e-mailed a brief description of the purpose of the interview and a simple example of what relative weights are and how they are going to be elicited from the participant during the interview. This e-mail is presented as Appendix L. At the beginning of the interview, the interviewee is asked if they have any questions about the purpose of the interview, what the weighting of the issues mean, and the process in which the interview is conducted. The interviewee

is also instructed to focus answers based upon a crisis-action, AEF deployment to the SWA theater in which the *primary* purpose of the deployment was to conduct combat operations.

As with the e-mail questionnaire, the interviewees are asked to individually compare two separate campaign specific issues to determine the relative weighting of each. Unlike the e-mail questionnaire, the interviewees are given a visual diagram of the range of measurement of each issue compared, and are given a range of measurement in which each issue is compared. A typical setup of the weight elicitation process is presented as Figure 4.

Issue 'A' is compared to Issue 'B' along their ranges of measurement. The interviewee is first presented with the ranges of measurement, which are typically only a portion of the full range of measurement obtained by CENTAF during the Value Focused Thinking interviews. The interviewee is then presented with two alternatives, an example of which is shown in Figure 4, where campaign specific issues 'A' and 'B' is compared.

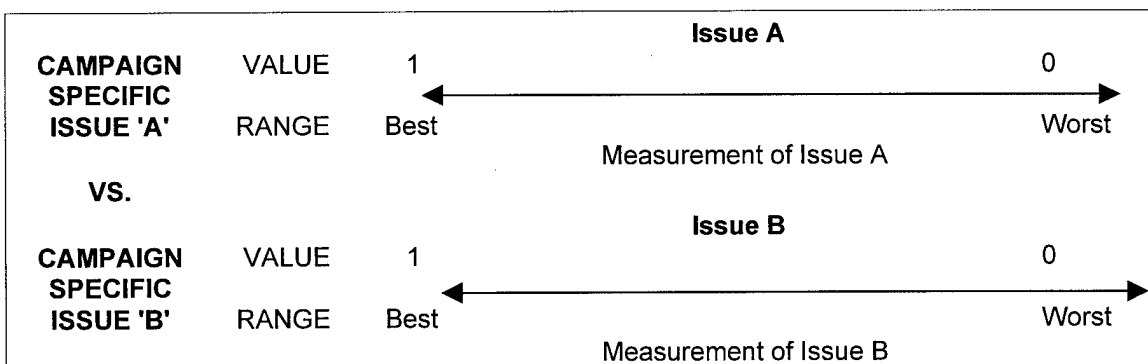


FIGURE 4: Weight comparison of Issue 'A' and Issue 'B'.

The interviewee is instructed that for both alternatives, all other campaign specific issues and aspects of the deployment should be considered equivalent to both

alternatives. This means that looking at both alternatives, the only two things that are different about the alternatives are with respect to issues 'A' and 'B'. Based upon the previous round of the Delphi study, issue 'A' was ranked higher in importance than issue 'B', and are therefore discussed to determine the portion of the range of measurement of issue 'A' that equaled the *entire* range of measurement of issue 'B'. The alternatives are then discussed. For the first alternative, issue 'A' has a very high measurable score (highest-value based upon the identified range of measurement). Issue 'B', for this first alternative, has a very low measurable score (lowest-value based upon the identified range of measurement). For the second alternative, Issue 'B' has a very high measurable score (highest-value based upon the identified range of measurement). The following question and statement are then proposed:

If, for this second alternative, Issue 'B' could command a very high value, what loss of Issue 'A' would you be willing to accept to be indifferent to selecting either alternative? At this score of Issue 'A', if Issue 'A' had a higher score (higher value), you would always select the second alternative; if Issue 'A' had a lower score (lower value), you would always select the first alternative. For these two alternatives, all other issues are held constant.

Sixteen comparison questions are asked to determine the relative weighting between parent issues and between sub-issues within each parent issue. This number of questions is needed to properly compare sub-issues within a particular parent issue, and to compare parent issues to each other. As with the e-mail questionnaire, the parent issues are determined by comparing the two highest-ranking issues, as determined by the first round of the Delphi study.

Once the relative weights, based upon ranges of measurement, of the campaign specific issues are obtained from the interviewees, the weights are transformed to reflect the value of each campaign specific issue. Using the model, the value of the high and low range of measurement for each issue is calculated. The analysis of the interview data is then based upon comparing values, and the information obtained from the e-mail questionnaires was added to the data. To determine the relative weights for each issue within a particular parent issue, the relative weighting of each sub-issue must sum to 1, as shown in Equation 2. The comparisons of individual sub-issues within a unique parent issue allow an equation to be developed that contains only 1 sub-issue. An example of this is the *Enemy* parent issue. Two questions in both the interview elicitation and the e-mail questionnaire are dedicated to the three sub-issues of the *Enemy* parent issue. The first question compares *USAF vs. Enemy Capability* to *Enemy ISR*, and the second question compares *USAF vs. Enemy Capability* to *Enemy Interference*. Looking at Equation 2, it is held that the relative weights of *USAF vs. Enemy Capability*, *Enemy ISR*, and *Enemy Interference* must sum to 1. Because *Enemy Capability* and *Enemy ISR* are both compared to *USAF vs. Enemy Capability*, the variables in Equation 2 are reduced to only the *USAF vs. Enemy Capability* issue. Once the relative weight of the *USAF vs. Enemy Capability* issue is determined, the comparisons are used to determine the relative weights of both *Enemy ISR* and *Enemy Capability*. This process is repeated to determine the relative weights for each of the sub-issues within a particular parent issue.

Parent issue weights are determined using the same method. Using Equation 2, the parent issues must sum to 1. Based upon the Campaign Specific Issue value

hierarchy updated through the first round of the Delphi study, only three comparisons are needed.

To complete the Value Focused Thinking (VFT) Campaign Issue analysis model, the relative weights of the sub-issues must be transformed into *global weights*. Global weights are the true level of importance that a single issue has on the overall analysis of a particular asset set. Relative weights of sub-issues provide the portion of the parent issue's weight that affects the calculation. To transform relative weights to global weights, the relative weight of a particular sub-issue is multiplied by the relative weight of the parent issue that the particular sub-issue falls into. A set of global weights is calculated based upon each individual interview and e-mail questionnaire response given.

The second round of questionnaires is complete when a consensus of the SMEs is obtained on the numerical values of relative weights for each individual campaign-specific issue. With the development of relative weights, the campaign-specific decision support tool is complete.

SENSITIVITY ANALYSIS OF ISSUE WEIGHTS

Once the VFT model is developed, it can be used to conduct a sensitivity analysis to determine the impact of the ranking of alternatives based upon changes in the relative weighting of the parent issues. These parent-issue weights represent the relative importance that is attached to the individual issues within the parent issue, and may be a topic of disagreement between the subject matter experts. To conduct the sensitivity analysis the weight of a single parent issue will be evaluated, while holding the other weights to the same ratio as obtained from the Delphi study. All of the weights must sum to 1. In his textbook, Kirkwood describes the method of varying all other weights in the

hierarchy [Kirkwood, 1997: pg 84]. By varying the weight studied over a range of possible values for the weights, the sensitivity of the ranking of assets sets to the specific weight can be determined. While it is important to determine the sensitivity across the range of weights obtained from the SMEs, it is also important to understand how the rankings may change based upon weights outside of this identified range. If the ranking of the asset sets do not change within the range of weights provided, confidence in defined value for the studied weight is achieved. Multiple changes in rank within the range of weights provided suggest that there is disagreement between the SMEs as to the actual importance of this issue.

SUMMARY

This chapter details the development of the three stages of research on campaign-specific issues. First, the development of a CTA to elicit campaign-specific issues from deliberate and crisis action planning subject matter experts was discussed. The development and setup of a Value-Focused Thinking interview with crisis action planning staff members at Headquarters, United States Air Force Central Command is discussed. The Value-Focused Thinking interview obtains quantitative ranges of measurement for the measurable campaign-specific issues, within the context of a crisis action plan in the Southwest Asian Theater of operations. Finally, the development and setup of a Delphi study to obtain confirmation of the developed campaign-specific issues hierarchy and to determine relative weights of those campaign-specific issues within the Southwest Asia Theater is discussed.

The next chapter discusses the results obtained from the CTA, VFT interview, and Delphi study. The integration of these three studies lead to the development of a

campaign-specific decision support tool to aid crisis action planners in assessing the potential impact of non-technical issues on the selection and deployment of a specific set of combat aircraft.

IV. RESULTS

PHASE I – CTA STUDY

During the CDM interview process, individual interviews lasted between one and two-and-one-half hours, depending upon the level of interest and quantity of discussion provided by the interviewee. As the interviews were largely unstructured, it was felt that setting a limit of the interview time could lead to missing out on potentially valuable information.

All of the subject matter experts (SMEs) contacted were very supportive of the research and took the time not only to undergo the interview but to understand the overall objectives of the research. At the conclusion of each group (Air Combat Command, Air Staff, and Air University) of interviews, hand-written dictation of the interviews were transcribed into electronic media. Interview notes from these interviews, with names omitted, are presented as Appendix H.

Campaign Specific Issues:

At the completion of all interviews, the interview notes were reviewed to determine relevant campaign specific issues. The issues repeatedly identified through the interviews with the SMEs were incorporated into the value hierarchy. The updated value hierarchy is presented as Figure 5.

From the CTA interviews, descriptions of the campaign specific issues were obtained. Individual descriptions of campaign specific issues are ordered according to their parent issue, as shown in Figure 5. For example, the first definitions presented are those under the *Host Nation* factor, the left-most parent issue in the tier below *Campaign Specific Issues* in the hierarchy.

Campaign Issues

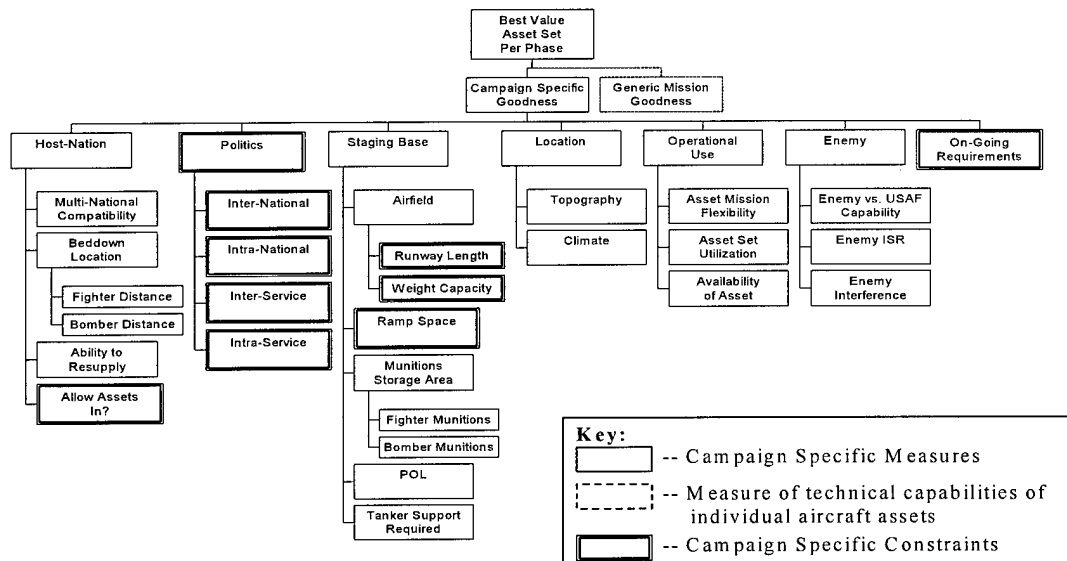


FIGURE 5: Updated campaign issues Phase II value hierarchy.

HOST NATION ISSUES:

Multi-National Compatibility. The extent to which host-nation assets, to include combat aircraft, equipment, spares, and support equipment can be incorporated alongside and into USAF combat aircraft.

Beddown Location: Fighter Distance. The effectiveness of an individual fighter asset within the asset set is dependent upon the distance from the staging base to the target. This issue will result in a different level of value to the theater commander depending upon whether fighter aircraft assets could obtain aerial refueling between the staging base and the enemy target, and whether fighter or bomber assets were being used.

Beddown Location: Bomber Distance. The effectiveness of an individual bomber asset within the asset set is dependent upon the distance from the staging base to the target.

This issue results in a different level of value to the theater commander depending upon whether bomber aircraft assets could obtain aerial refueling between the staging base and the enemy target, and whether fighter or bomber assets are being used.

Re-supply Ability. Sustained combat operations from the staging base are dependent upon the ability of USAF force's equipment and materials to be resupplied. Assuming the staging base has been predetermined, the selection of combat aircraft assets is dependent upon individual asset's resupply requirements. Combat aircraft that require smaller amounts of POL, munitions, and other equipment have a higher inherent value than an aircraft type that requires more assets.

Allow Assets In. This issue is a constraint. A Host-Nation political issue regarding whether or not the specific combat aircraft assets in a particular asset set can be allowed into the combat theater and into the country where the staging base is located. Either the assets in the particular asset set can be allowed into the theater and host-nation or they cannot be allowed into the theater and host-nation.

POLITICAL ISSUES:

International Politics. This issue is a constraint. This issue assesses whether international political issues, such as economics, trade pacts, or host-nation requirements (i.e. the host-nation will not allow offensive platforms onto their soil or over their airspace), influence the allowance of a particular asset set.

Intra-national Politics. This issue is a constraint. This issue assesses whether intra-national political issues, such as national economics or congressional debates (i.e. one state's congressional representative pushing for a deployment tasking at the base and base assets within their particular district), influence the allowance of a particular asset set.

Inter-service Politics. This issue is a constraint. This issue assesses whether inter-service political issues, such as current department of defense policies or command leveling (i.e. the desire to distribute deployment requirements across Army, Navy, Air Force, and Marine forces), influence the allowance of a particular asset set.

Intra-service Politics. This issue is a constraint. This issue assesses whether intra-service political issues, such as squadron rotational requirements or asset use desires (i.e. the desire to show the capabilities of the B-2), influence the allowance of a particular asset set.

STAGING BASE ISSUES:

Airfield Issues: Runway Length. This issue is a constraint. The length of the runway at the pre-determined staging base determines whether the combat aircraft within a particular aircraft asset set can land and takeoff at that staging base. This issue assesses whether or not all of the combat aircraft within a particular aircraft asset set can land and takeoff from the pre-determined staging base.

Airfield Issues: Weight Capacity. This issue is a constraint. The weight bearing capacity of the runway, taxiways, and ramp space at the pre-determined staging base determines whether the combat aircraft within a particular aircraft asset set can conduct operations from the pre-determined staging base. This issue assesses whether or not all of the combat aircraft within a particular aircraft asset set can conduct operations from the pre-determined staging base.

Ramp Space. This issue is a constraint. This issue assesses the capacity at the pre-determined staging base to beddown all of the combat aircraft within a particular aircraft

asset set. The staging base is either able or not able to beddown all of the combat aircraft within a particular aircraft asset set.

Munitions Storage: Fighter Assets. The Continued fighter operations depend heavily on the pre-determined staging base's ability to store specific munitions for fighter operations. Fighter aircraft can only bring one load of munitions; additional sorties require the ability of the staging base to re-load the fighter.

Munitions Storage: Bomber Assets. The Continued bomber operations depend on the pre-determined staging base's ability to store specific munitions for bomber operations. Bomber aircraft can only bring one load of munitions; additional sorties require the ability of the staging base to re-load the bomber.

Petroleum, Oil, and Lubricants (POL) Capability. The staging base's POL system includes storage and supply from both military and host-nation contracted sources. POL capability for a particular asset set must take into consideration the per-sortie POL requirements of each individual aircraft in the asset set as well as the daily sortie requirements for each individual aircraft.

Tanker Support Required. Depending upon the location of the staging base from the enemy target and the fuel requirements per aircraft asset sortie, and the number of aircraft assets conducting sorties at a particular time, multiple tanker assets may be required.

LOCATION ISSUES:

Topography. This issue measures the extent to which natural and man-made land formations around the pre-determined staging base affect the ability of individual aircraft assets within an asset set to take-off and land at the staging base.

Climate. This issue measures the extent to which heat, humidity, adverse wind and atmospheric pressure affect the ability of particular aircraft assets to conduct combat operations.

OPERATIONAL USE ISSUES:

Availability of Assets. This issue measures the extent to which aircraft assets in the asset set are operationally capable of being used to conduct aerospace missions required by the theater commander.

Asset Mission Flexibility. This issue measures the extent to which the aircraft within the asset set can perform all of the possible aerospace missions defined in AFM 1-1 and AFDD 2-1. The relative worth of the asset set is high if that asset set could perform any mission required by the theater commander.

Asset Set Utilization. The extent to which aircraft in the asset set are used to perform aerospace missions as required by the theater commander. This assumes that aircraft brought into the theater are used to conduct combat sorties and are not brought in only as a show of force.

Asset Set Over-Utilization. The extent to which aircraft in the asset set are over-used to perform aerospace missions as required by the theater commander. This assumes that aircraft brought into the theater are being used beyond their operationally sustainable maximum limit.

ENEMY ISSUES:

Enemy Ability and Capabilities versus Asset Set. This issue measures the comparison of enemy assets to USAF combat aircraft assets. Assuming US intelligence can determine the extent of the enemy's capability, this issue shows the relative worth of the amount of

aircraft assets brought into the pre-determined staging base. One consideration within this issue is the number of USAF combat aircraft brought into the staging base; another consideration is the capabilities of the enemy to counter the USAF combat aircraft brought into the staging base.

Enemy Intelligence, Surveillance, and Reconnaissance (ISR). This issue captures the enemy's ability to see or obtain information on US activity at the pre-determined staging base. Enemy ISR can be obtained through aerial or satellite photography, local sympathizers monitoring US activity, or spies within the host-nation working within or around the staging base.

Enemy Interference. This issue captures the enemy's ability to interfere with US operations at the pre-determined staging base. Enemy interference is any action on the part of the enemy that hampers US combat operations. Enemy interference could range from picketing and loitering around the staging base, isolated attempts to gain access into the base and base operations, bomb threats, attacks on aircraft taking off and landing at the base, or attacks on the base itself.

ON-GOING ISSUES:

On-Going Requirements. This issue is a constraint. This issue assesses whether or not enough of a particular type of asset is available to meet the number required in a particular asset set.

Once a list of campaign specific issues (developed through CTA interviews with Headquarters USAF, ACC, and Air University staff members working current and future deliberate and crisis action plans) had been developed into the value hierarchy shown in Figure 2, the value focused decision support tool could be developed. This author

believes that these campaign specific issues can be applied to any theater requiring USAF assets to respond to a contingency situation. However, the ranges of scoring that each aircraft and aircraft asset set may be given under any particular campaign specific issue may be different at separate theaters. Therefore, it is important to first develop the decision support tool to support a specific theater. This decision support tool was developed to focus on crisis-action planning, through a value-focused interview with members of the deliberate and crisis action planning offices at Headquarters, Air Force Central Command.

PHASE II – VALUE FOCUSED THINKING STUDY

The Crisis Action Planning office at Headquarters, Air Force Central Command (CENTAF), was contacted to participate in the Value Focused Thinking (VFT) interview to develop quantitative ranges of scores for each of the factors presented in Figure 5. During the visit, three other CENTAF campaign planners were also interviewed. Two separate interviews were conducted.

At the beginning of the interview, the interviewees were given a brief introduction to Value-Focused Thinking. The new car purchase example in Appendix E was presented and used to familiarize the interviewees with the goals of the interview and to gain an understanding on how the interview would be conducted. Once the interviewees were confident that they understood the process, the value elicitation began.

The value elicitation interview was setup as discussed in the Phase II methodology section of this paper. The interview was conducted by showing a single campaign specific issue graph to the interviewee and eliciting how the graphical function, converting the specific issue's measurement to value, would look. First, the interviewee

was asked if the X-axis measurement made sense for the specific issue, and if some different scale or measurement would be more effective. In several instances, the pre-determined measures were adjusted based upon the interviewee's knowledge and understanding of campaign planning.

Some of the campaign specific issue measurements were changed during the group interview. For instance, the measurement for the *Ability to Resupply* variable was adjusted to better reflect the commander's views and requirements. This measurement had originally been developed to measure the distance of the pre-determined staging base to the supply Point of Debarkation (POD). This measurement was changed to a ratio of consumption to resupply. The interviewee group, comparing possible alterations to the measurement, stated that the ratio function was better suited to assisting campaign planners in selecting the best set of aircraft assets to respond to a theater crisis. The *Tanker Support Required*, *Enemy*, and *Political* issues were also adjusted during the interview as to how they were measured in order to better reflect the views and requirements of the theater commander.

Once the graphical functions were obtained from the Headquarters, USAF Central Command campaign planning staff, the functions were incorporated into an Excel spreadsheet. The campaign specific planning issues were incorporated into the decision support tool using graphical function equations developed by Kirkwood [Kirkwood, 1997; pg 75-85].

During the coding of these functions, it was noted that 5 value functions, elicited from the two separate group interviews, were dissimilar. The issues in question were *Climate*, *POL*, *Asset-Mission Flexibility*, *MSA Fighter Support*, and *MSA Bomber*

Support. An individual Excel worksheet for each of the separate issues was developed, presenting both of the dissimilar graphical functions. These worksheets were then e-mailed to the interviewees individually, so that they could compare the opposing graphical functions of each issue in question and provide feedback on which graphical representation was better, or if there was another representation that better suited the measurement of these individual issues. For each issue in question, the campaign planners at Headquarters, USAF Central Command individually concurred with a single graphical representation. The agreed upon graphical representation for each issue has been incorporated into the decision support tool. The graphical representation for each individual campaign specific issue, along with the definitions and quantitative measurement values, are presented collectively as Appendix I.

The final step in developing the Value Focused decision support tool was to obtain relative weights for each of the campaign specific issues. Even more than the measurements of the issues themselves, the weights of these campaign specific issues may be very dependent upon the location or theater in which the crisis is taking place. A Delphi study was applied in Phase III of this research to obtain consensus of the value hierarchy as developed from all subject matter experts queried in this research. The Delphi study was also used to obtain Southwest Asia Theater specific weights for each of the campaign specific issues.

PHASE III – DELPHI STUDY

Ten of the 25 SMEs returned a completed first questionnaire, for a response rate of 40 percent. Five other SMEs stated that they could not complete the survey due to

business requirements, but would try to complete the second questionnaire when it was received. Overall, the reply rate of the first round was 60 percent. Of the three purposes for this first round of the Delphi study, this questionnaire satisfied the first of its three purposes. Presented as Appendix K, there were a number of constructive comments regarding the configuration of campaign specific issues within the value hierarchy. As expected however, this first questionnaire did not provide any clear picture as to a consensus of the relative ranking of individual campaign specific issues. The individual rankings of campaign specific issues are presented in Table 3. Campaign specific issues in italic font represent campaign specific constraints; they are either *yes* or *no* alternatives and do not possess value functions as do the campaign specific issues presented in Appendix I. Note that a general trend among the responding participants can be seen with respect to the issues believed to be most-potentially influential and the least-potentially influential. *Allow Assets In* and *Intra-National Politics* were generally ranked as potentially having a large influence on the selection of combat aircraft. Conversely, *Multi-National Compatibility*, *Intra-Service* and *Inter-Service Politics*, *Topography*, *Climate*, and *On-Going Requirements* were generally ranked as potentially having a small influence on the selection of combat aircraft. Based upon the results of this first questionnaire, the second questionnaire was built. The purpose of the second questionnaire was to elicit discussion on the comments obtained from the first questionnaire, and to present the rankings obtained from the first questionnaire in an effort to obtain a more discernable trend to the individual rankings.

The second questionnaire in this first round was developed similar to the first questionnaire. The two basic questions, as proposed in the first round, were asked. For

Question A in this round, the comments obtained from the first round were summarized and provided. Each survey participant was asked to provide feedback and discussion on the comments, whether positive or negative. The experts were again asked about the ranking of the campaign specific issues based upon their knowledge and expertise for *Question B*.

TABLE 3: Delphi Study Questionnaire 1 Ranking Results											
CAMPAIGN SPECIFIC ISSUES	INDIVIDUAL RESPONSES										
	ACC 4	ACC 5	ACC 6	ACC 7	CAF 2	HQ 2	HQ 3	HQ 4	AU 1	AU 2	
Multi-National Capability	15	21	19	22	23	22	22	24	21	18	
Beddown Location: Fighter Distance	16	10	11	5	4	10	8	2	8	7	
Beddown Location: Bomber Distance	21	10	12	6	11	17	8	3	19	8	
Ability to Resupply	11	17	10	17	15	18	19	23	6	9	
Allow Assets In	1	18	1	4	1	2	3	1	1	10	
Inter-National Politics	2	1	2	2	17	1	9	10	3	5	
Intra-National Politics	3	2	13	3	18	7	9	11	2	23	
Inter-Service Politics	25	23	18	23	19	6	20	22	22	21	
Intra-Service Politics	26	24	26	24	20	22	21	21	23	22	
Airfield: Runway Length	13	11	5	7	6	8	4	12	17	4	
Airfield: Weight Capacity	14	12	6	8	14	9	4	13	18	5	
Ramp Space	12	13	3	9	3	22	5	14	11	6	
Munitions Storage Area: Fighter Munitions	9	14	7	10	7	12	6	15	9	14	
Munitions Storage Area: Bomber Munitions	10	14	8	11	12	21	6	16	20	15	
Petroleum, Oil, and Lubricants	7	15	4	12	5	13	7	17	10	5	
Tanker Support Required	8	16	14	13	13	11	16	4	7	12	
Topography	23	20	16	26	24	19	17	18	5	16	
Climate	22	19	17	25	25	20	18	19	4	17	
Asset Mission Flexibility	18	4	23	21	2	14	1	25	12	2	
Asset Set Utilization	19	5	24	19	16	15	2	26	24	13	
Asset Set Over-Utilization	17	6	25	20	21	16	11	20	25	18	
Availability of Asset	20	3	9	18	22	5	10	5	16	11	
Enemy Vs. USAF Capability	5	7	21	14	8	3	12	6	14	19	
Enemy ISR	6	8	15	15	9	4	15	9	13	1	
Enemy Interference	4	9	20	16	10	4	14	8	15	20	
On-Going Requirements	24	22	22	1	26	23	13	7	26	3	

However, in this round, the rankings obtained from the first questionnaire were provided to the experts. The previous questionnaire's findings were presented to the study group

in this second questionnaire to provide feedback as to the range of rankings obtained from the first questionnaire. The findings were also included to help those participants who did not complete the first questionnaire to both understand what is being asked of those participants and to provide them with a tool in which they could submit their opinions.

As there were only four responses to the second questionnaire at the time responses were requested, the questionnaire was rewritten and resent. A more concise, "Yes" or "No" question was asked of the survey pool members who did not respond to the second questionnaire. In this draft, the campaign specific issues were separated into three categories: most potentially important, potentially important, and least potentially important to the selection of combat aircraft to the SWA theater. Group number 1 corresponds to the most-potentially important issues, Group 2 corresponds to important issues, and Group 3 corresponds to least potentially important issues. If the participants did not agree with the groupings of the issues, they were asked to re-group the issues according to their group number. The short version of the second questionnaire received five additional responses, bringing the response rate of the second questionnaire up to 9 out of 25, or 36 percent. The initial grouping of Campaign Specific Issues for this questionnaire, accompanied by the answers provided by the study group respondents is presented as Table 4.

Based upon comments made during the first and second questionnaires of the first phase of the Delphi study, the Campaign Specific Issue value hierarchy was updated. The updated value hierarchy is shown as Figure 6.

TABLE 4: Delphi Study Questionnaire 2 Group Ranking Results										
CAMPAIGN SPECIFIC ISSUES	Initial given for use	RESPONSES								
		ACC 1	ACC 4	ACC 5	ACC 6	CAF 2	HQ 2	HQ 3	HQ 5	AU 2
Allow Assets In?	1	1	1	2	1	1	1	1	1	2
Inter-National Politics	1	1	1	1	1	1	1	1	1	2
Tanker Support Required	1	1	2	2	2	2	2	2	2	2
Asset-Mission Flexibility	1	1	2	1	3	1	1	1	2	1
Beddown Location: Fighter Dist	2	2	2	2	2	2	2	2	2	2
Beddown Location: Bomber Dist	2	2	2	2	2	2	2	2	2	2
Intra-National Politics	2	2	1	1	2	2	2	2	1	3
Inter-Service Politics	2	2	3	3	2	3	2	3	3	3
Airfield: Runway Length	2	2	2	2	1	2	2	2	2	1
Airfield: Weight Capacity	2	2	2	2	2	2	2	2	2	2
Ramp Space	2	2	2	2	1	2	2	2	2	2
MSA: Fighter munitions	2	2	2	2	2	2	2	2	2	2
MSA: Bomber munitions	2	2	2	2	2	2	2	2	2	2
POL	2	2	2	2	1	2	2	2	2	2
Topography	2	2	3	2	2	2	3	2	2	2
Climate	2	2	3	2	2	2	3	2	2	2
Asset Set Utilization	2	2	2	1	3	2	2	2	2	2
Asset Set Over-Utilization	2	2	2	2	3	3	1	2	2	2
Availability of Asset	2	2	2	1	2	3	2	2	1	2
USAF Vs. Enemy Capability	2	2	1	2	2	2	1	2	1	2
Enemy ISR	2	2	2	2	2	2	2	2	2	1
Enemy Interference	2	2	1	2	2	2	2	2	2	3
On-Going Requirements	2	2	3	3	3	3	2	2	2	1
Ability to Resupply	3	3	2	2	2	3	3	3	3	2
Multi-National Compatibility	3	3	2	2	2	3	3	3	3	2
Intra-Service Politics	3	3	3	3	3	3	2	3	3	3

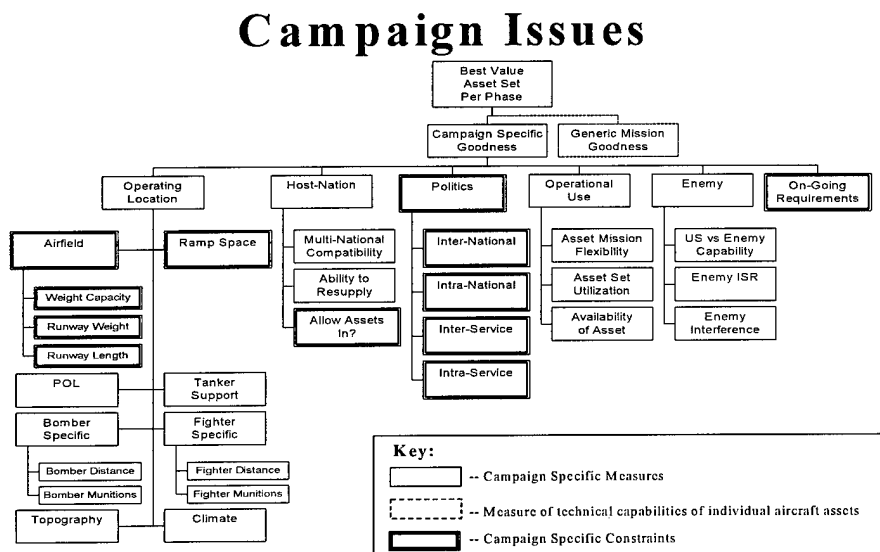


FIGURE 6: Delphi Study Updated campaign issues value hierarchy.

The first change included the movement of the fighter and bomber distance issues to the staging base parent issue. Secondly, the parent issue *Staging Base* was re-named *Operating Location*, because this term more accurately describes the location at which fighters and bombers conduct missions from. The term *Staging Base* may refer to locations where supplies and equipment are brought into theater from the continental US (CONUS), before they are shipped to the operating location. Additionally, the *Operating Location* for certain aircraft platforms, primarily bomber assets, may be located in CONUS. Also, fighter and bomber distance locations is not a *Host-Nation* issue. A third change was the addition of a *Runway Weight Capacity* constraint to the *Airfield* constraint issue. The weight capacity of the operating location runway may be an important issue to consider when bringing in certain aircraft assets. A final change was to regroup the distance and Munitions Storage Area (MSA) issues for both fighter and bomber assets. *Fighter Specific Issues*, which includes both fighter distance and MSA:

Fighter munitions, and *Bomber Specific Issues*, which includes both bomber distance and MSA: Bomber munitions, is a better representation of these issue.

15 of the 25 Delphi study pool members were given the third e-mail questionnaire. The individuals given the e-mail questionnaire were those that were not interviewed directly as a part of the second weighting elicitation method. 10 members of the Delphi study pool were contacted and interviewed.

Seven individual sets of weights were obtained through the interview and e-mail questionnaires. One set of parent-issue weights was obtained through an interview at HQ/USAF, for a total response rate of 32 percent. The individual sets of weights were transformed and entered into the decision support tool as described. For each of these individual sets of weights, final values for each asset set were then calculated. The top ten highest final value asset sets were then compared to see how the individual sets of weights impacted the model output. Based upon this analysis, it was determined that each of the individual sets of weights gave similar, but not equal rank ordering of asset sets. It was therefore determined that the individual sets of weights should be combined.

An average adjusted weight for each issue was developed using individual sets of weights that were adjusted based upon their organization. Because the decision support tool has been developed specifically for the SWA Theater, the set of weights obtained from CENTAF was quadrupled. Sets of weights obtained from ACC were doubled, and sets of weights obtained from Air University and HQ/USAF were not adjusted. Weights from ACC were doubled due to the current focus on the SWA Theater, but ACC is not as dedicated to the SWA Theater as is CENTAF. Air University and HQ/USAF were not

adjusted based on the belief that their campaign planning focus is spread throughout all possible theaters, not just the SWA Theater. The adjusted weights were then summed and then divided by the total adjusted number of sets of weights. One set of weights was obtained from CENTAF, three sets of weights were obtained from ACC, and one set each of weights was obtained from Air University and HQ/USAF. These averaged, adjusted weights in the model, along with the range of weights calculated for each campaign specific issue, is presented in Table 5. A discussion on the sensitivity analysis of these weights as they may affect the final value of the alternative asset sets is presented in the next section of this chapter.

The second questionnaire in this phase of the Delphi study was used to confirm the adjusted weights for each individual campaign specific issue. This questionnaire was also used to confirm changes made to the campaign specific issue value hierarchy from the comments made in the first phase of the Delphi study. As with the first two questionnaires, the survey participants were e-mailed the questionnaire and asked to reply by e-mail with their responses. For this questionnaire, three individual survey participants from ACC were not included. These individuals were not included because of a disinterest in this research, and it was felt that the inclusion of these individuals within this final round would not be beneficial to any of the parties involved.

TABLE 5: Delphi Study Identified Global Weights			
Campaign Specific Issue	Global Weight Identified		
	Low	Adjusted Average	High
HOST NATION			
Multi-National Compatibility	0.0039	0.068	0.1392
Ability to Resupply	0.0825	0.174	0.3230
OPERATING LOCATION			
Beddown Location: Fighter Dist	0.0114	0.024	0.0360
Beddown Location: Bomber Dist	0.0240	0.099	0.1480
POL	0.0209	0.058	0.1200
MSA: Fighter munitions	0.0133	0.037	0.0480
MSA: Bomber munitions	0.0133	0.032	0.0480
Tanker Support Required	0.0152	0.060	0.2820
Climate	0.0038	0.015	0.0240
Topography	0.0019	0.018	0.0320
OPERATIONAL USE			
Asset-Mission Flexibility	0.0336	0.067	0.0825
Availability of Asset	0.0272	0.064	0.1045
Asset Set Utilization	0.0323	0.051	0.0992
ENEMY			
USAF Vs. Enemy Capability	0.0660	0.118	0.1440
Enemy ISR	0.0012	0.046	0.1023
Enemy Interference	0.0360	0.071	0.1110

Eight of the remaining 22 survey participants replied to the fourth questionnaire, for a response rate of 36 percent. Based upon the responses provided, no changes were made to the campaign specific issue value hierarchy or the individual weights of the issues within the hierarchy.

SENSITIVITY ANALYSIS OF CAMPAIGN-SPECIFIC ISSUE WEIGHTS

Because no consensus was reached for the individual global issue weights, a sensitivity analysis was conducted on the parent campaign-specific issue weights. The purpose of this analysis is to identify how changes in the weight of each of the parent issues affect the relative value of an individual asset set. While the weights may change, simply changing the weights does not change the value of every alternative. It is

important to note that all though the data is notional, this data will not affect changes in the ranking of individual asset sets in the same manner as will the real-world developed issue weightings.

Using the developed adjusted average weights presented in Table 5, a sensitivity analysis was separately conducted on each of the four parent issues: *Host Nation*, *Operational Location*, *Operations*, and *Enemy*. The sensitivity analyses were conducted by swinging the global weights of the tested parent issue from 10-percent to 90-percent, maintaining the same ratio for the other three weights. At some point in each of the analyses, the asset set identified as having the highest total value (best value) changed. Figure 7 presents the highest total value asset sets along the range of weighting of the *Host Nation* issue. Figure 8 presents the highest total value asset sets along the range of weighting of the *Operational Location* issue. Figure 9 presents the highest total value asset sets along the range of weighting of the *Operations* issue. Figure 10 presents the highest total value asset sets along the range of weighting of the *Enemy* issue.

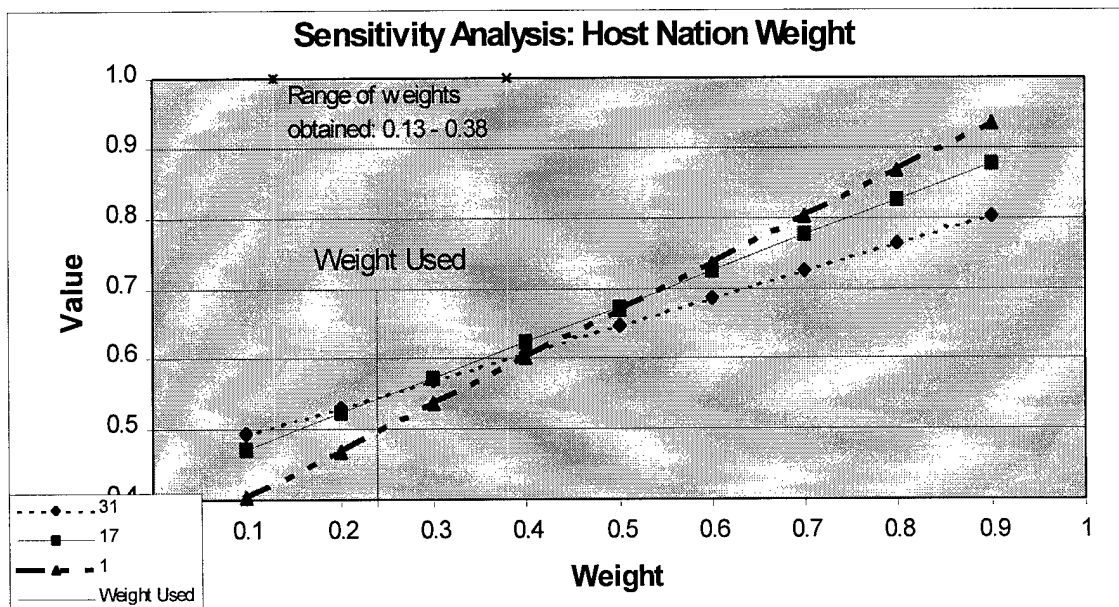


FIGURE 7: Sensitivity analysis on *Host Nation* global weight

As shown in Figure 7, Asset set #31 has the highest final value at low values of the *Host Nation* global weight. Correspondingly, when The Host Nation weight is low and the Operation Location weight is high, Asset set #31 has the top rank. This indicates that Asset set #31 is generally a robust asset set in terms of value. As the *Host Nation* global weight increases, we can see that Asset set #1 increases in total value, becoming the top-value asset set. This is evident in that Asset set #1 has a top-score value (1.0) for both *Multi-National Compatibility* and *Resupply Ability* issues, which drives the total value when *Host Nation* is the most importantly weighted parent issue. Looking over the range of global weights obtained from the Delphi study, Asset sets #31 and #17 are the top-value alternatives. Comparing the individual responses to the range in Figure 7, weights corresponding to the selection of Asset set #31 were generally seen by subject matter experts (SMEs) from HQ/USAF, ACC, and AU. Weights corresponding to the selection of Asset set #17 were seen by SMEs from CENTAF.

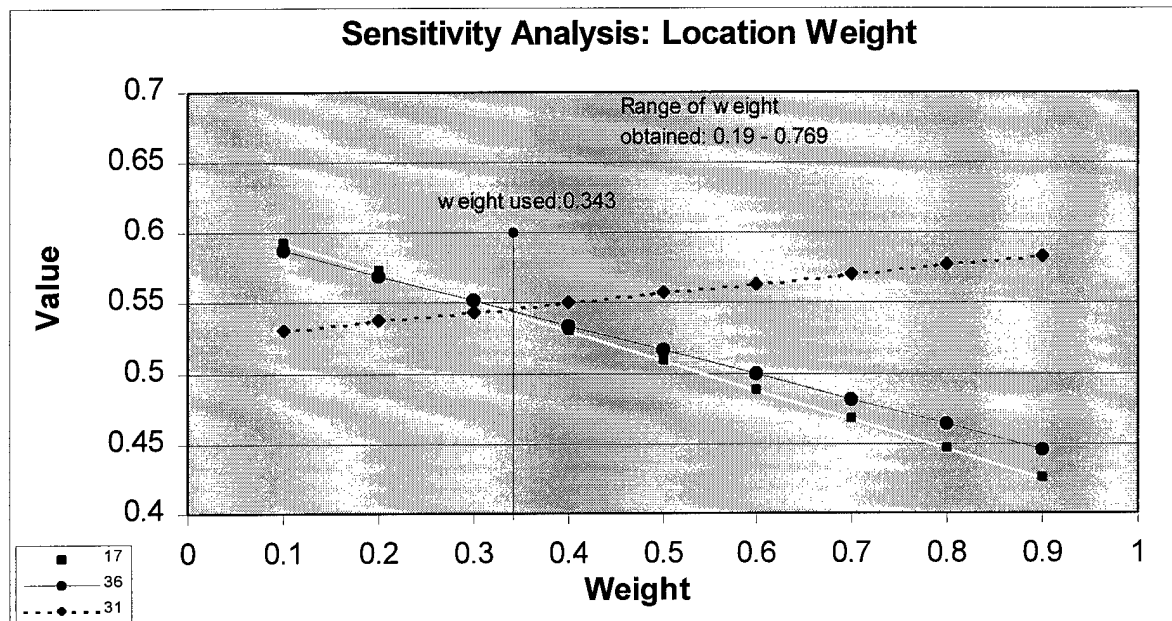


FIGURE 8: Sensitivity analysis of *Operation Location* global weight

As shown in Figure 8, Asset sets #17 and #36 are very similar in total value throughout the range of possible *Operation Location* issue weight. The main difference between Asset sets #17 and #31 are with respect to their value contributed from the *Beddown Location: Bomber Assets* and *POL* issues. These two issues do have a relatively high individual weight, compared to the other campaign-specific issues. Throughout the range of global weights obtained from the Delphi study, Asset sets #31 and #17 remain the top-value alternatives. Comparing the individual responses to the range in Figure 8, global weights corresponding to the selection of Asset set #17 were seen by CENTAF. Global weights corresponding to the selection of Asset set #31 were generally seen by subject matter experts (SMEs) from HQ/USAF and AU. ACC SMEs provided weights that corresponded to both Asset sets.

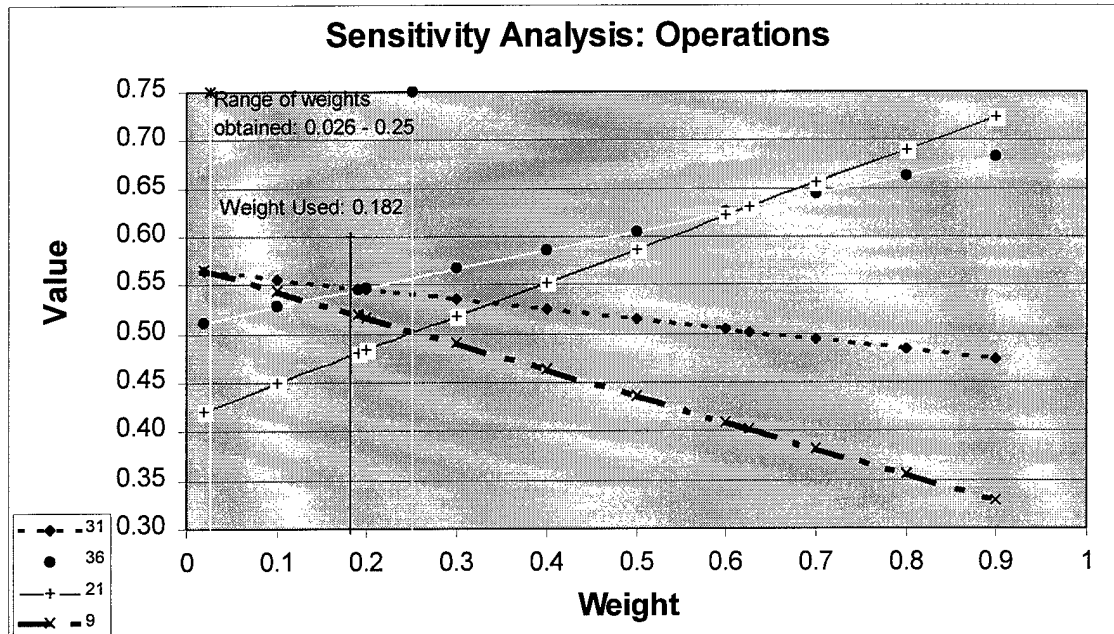


FIGURE 9: Sensitivity analysis on *Operations* global weight

As shown in Figure 9, Asset sets #21 and #36 generally have the same characteristics as the *Operations* parent issue global weight is swung from a low value to a high value. At a high weight for the *Operations* issues, relative to the other three parent issues, Asset set #21 has the highest total value. This is evident due to the individual high values given under the *Availability* and *Flexibility* issues, both of which have relatively high individual weights. At a low global weight for the *Operations* issues, relative to the other three parent issues, Asset set #31 has the highest total value. At the extreme low global weight of 0.02, Asset set #9 becomes the set with the highest total value. Looking over the range of global weights obtained from the Delphi study, Asset sets #31 and #36 are the top-value alternatives. Comparing the individual responses to the range in Figure 9, global weights corresponding to the selection of Asset set #31 were seen by AU. Global weights corresponding to the selection of both Asset set #31 and #36 were generally seen by subject matter experts (SMEs) from HQ/USAF, ACC, and CENTAF, depending upon the SME interviewed.

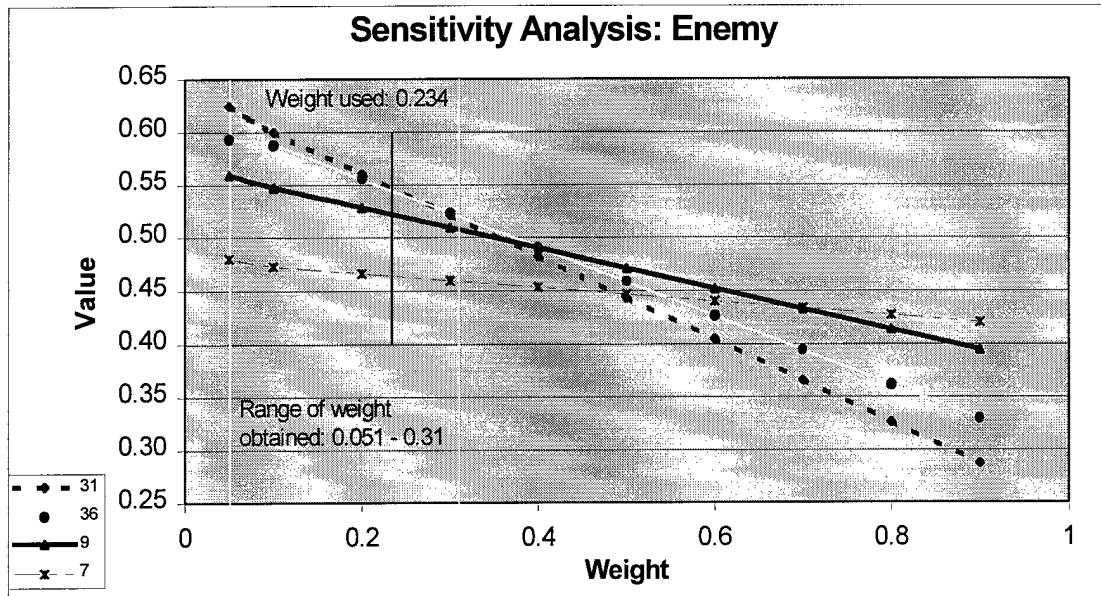


FIGURE 10: Sensitivity analysis of *Enemy* global weight

As shown in Figure 10, the *Enemy* parent issue is very sensitive to changes in global weight as compared to the other three parent issues. The highest value asset set changes 4 times over the range of *Enemy* parent issue global weight. But for the range of global weights obtained, there is no change in the order of these asset sets. This implies that the subject matter experts seem to be in agreement about the importance of *Enemy* issues. At a high value for *Enemy* global weight, Asset set #7 has the highest total value. This is evident due to the top-score value (1.0) for the *Enemy Interference* issue, and relatively high value for the *Enemy ISR* issue. While Asset sets #36 actually has a higher individual value for the *Enemy ISR* issue, the higher individual values for the non-*Enemy* issues give Asset set #7 a higher total value. This is evident when the *Enemy* parent issue global weight is smaller, where Asset set #7 has a lower total value than the other three contending best-value asset sets shown. Looking over the range of global weights obtained from the Delphi study, Asset sets #31 and #36 are the top-value alternatives. Comparing the individual responses, weights corresponding to the selection of Asset set

#31 were seen by SME from each of the four agencies. One set of weights from an ACC SME corresponded to the selection of Asset set #36, showing that there is some disagreement between ACC campaign planners.

DEVELOPED DECISION-SUPPORT TOOL

Through the analysis of results from each phase of the research, a Value Focused Thinking (VFT) Decision Support Tool to assist campaign planners in selecting a better set of combat aircraft to deploy in response to a Southwest Asian theater crisis action has been developed. The campaign specific issue decision support tool was developed using the M.T. Winthrop, Excel-based VFT analysis spreadsheet [Winthrop, 1999].

Within the decision support tool, the Campaign Specific Issue value hierarchy is presented. Hyperlinks on each campaign specific issue connects that issue to a spreadsheet that describes the issue and provides the mathematical connection between the range of measurement of the specific issue and value.

The range of measurements and correlating values were defined and calculated through the VFT interview with CENTAF. These measurement-to-value correlations are used in the mathematical analysis of alternative sets of assets. Descriptions for the Campaign Specific constraints are also provided. An individual worksheet is dedicated to each single Campaign Specific Issue and Constraint.

Following these worksheets, the calculation of relative and global weights is presented. This series of worksheets is used to provide the weighting information obtained from the Delphi study questionnaire and interviews, as well as the calculations to determine the individual Campaign Specific Issue weightings used in the mathematical analysis of alternative sets of assets.

Following the *weight* spreadsheets, imported information on the alternative sets of assets is presented. This information, based on Major Swartz's Asset Set Pilot Problem, provides information specific to the mathematical analysis of the asset set [Swartz, 1999]. This information, coupled with the mathematical value data and global weight data, is used to develop the *calculation* worksheet.

The *calculation* worksheet is used to determine the relative value, from 1 to 0, of each alternative set of assets, based upon the analysis of the campaign specific issues. An asset set with a value of 1 would provide the theater commander with the best total value, based upon the analysis of the campaign specific issues. Conversely, an asset set with a value of 0 would either be determined to be infeasible based upon the analysis of the Campaign Specific Constraints.

The worksheets that follow the *calculation* worksheet provide the campaign planner with a graphical representation of the value of the alternative asset sets based upon the Campaign Specific Issues. Looking at the absolute capabilities of the combat aircraft comprising an asset set, each unique set of assets is equally capable of completing the missions required by the Theater Commander. The value of an alternative asset set is compared to the amount of lift required to deploy that set of assets to the SWA Theater. Sets of assets with a higher value compared to the amount of lift required to deploy them are considered better than those sets that have a lower value with the same amount of lift required. Likewise, sets of assets with a lower amount of lift required to deploy that set is considered better than those sets that require additional lift for the same value.

The Campaign Specific Issue Decision Support Tool was run using the 50 notional asset sets identified through the AFIT/ALP Pilot Problem. For each asset set,

notional data was for all campaign specific issues was imported into the spreadsheet. Applying this notional information to the campaign specific value functions, the 50 asset sets were analyzed.

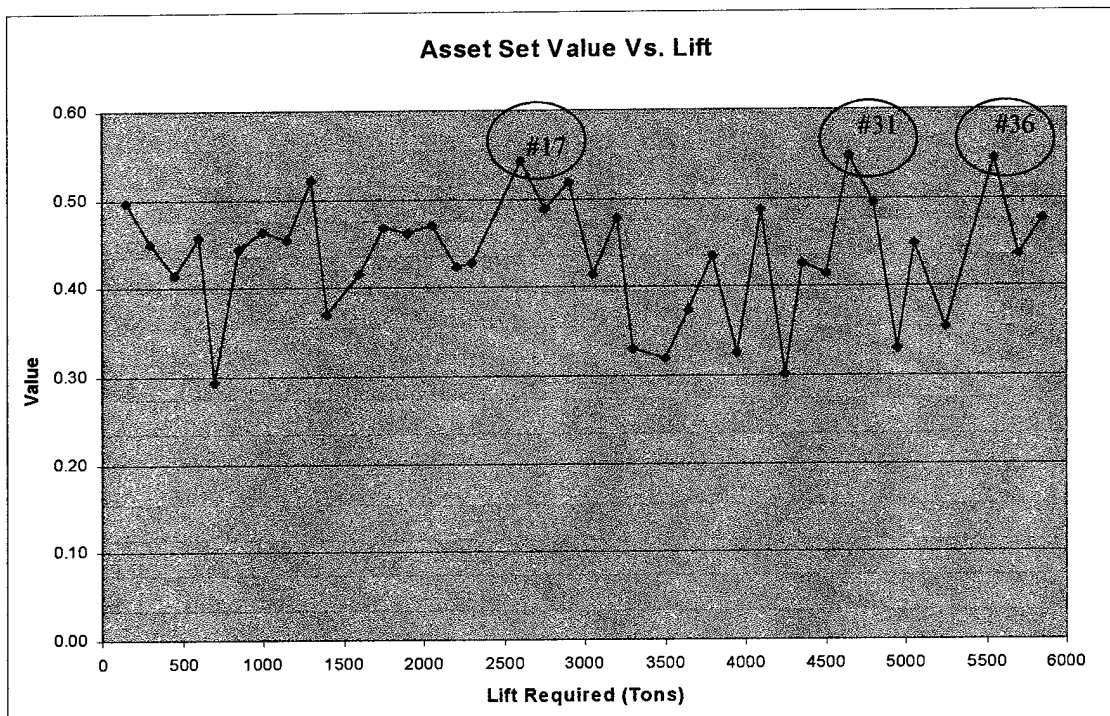


FIGURE 11: Value of AFIT/ALP Pilot Problem Asset Sets vs. Lift required

Once the relative value of each asset set was determined, the asset sets were compared against the lift (notional) required to deploy that particular asset set. A graphical analysis of the relative value of notional AFIT/ALP Pilot Problem asset set versus the notional lift required to deploy the asset set is shown as Figure 11. Note that, based on this notional example, Asset set #17 labeled on Figure 11 has a very high value (relative to the other asset sets) while not requiring as much lift as the other asset sets with equivalent value (Asset sets #31 and #36). Campaign Planners can also use this to single out a group of high value asset sets for further study or presentation as options to the Joint Air Component Commander and/or Joint Forces Commander.

The Campaign Specific Issue Decision Support Tool will be integrated into the AFIT/ALP Asset Selection tool. Actual aircraft specific information, required within the decision support tool, will be provided through the Advanced Logistics Project database system.

SUMMARY

This chapter has detailed the results of each phase of the research, leading to the development and testing of a Campaign Specific Issue Decision Support Tool. A Campaign Specific Issue value hierarchy was developed through review of current Air Force and Joint Publications and revised through several rounds of interviews and questionnaires. With respect to a Southwest Asian (SWA) Theater, Air Expeditionary Force (AEF) deployment, ranges of measurement were identified for each of the Campaign Specific Issues within the value hierarchy. Relative weights of Campaign Specific Issues were determined, where the purpose of this AEF deployment to the SWA Theater was to conduct combat operations in a decisive enemy halt scenario. A decision support tool to study these Campaign Specific Issues was then developed and tested using AFIT/ALP Pilot Problem asset sets.

The next and final chapter of this document will discuss the conclusions, successes, and limitations of this research. Possible follow-on research will also be suggested.

V. CONCLUSION

INTRODUCTION

In Chapter 1, it was stated that the Advanced Logistics Project (ALP), if proven successful, would provide a methodology to quickly develop a detailed deployment plan, whereby campaign planners will have the opportunity to compare multiple deployment scenarios and schedules. Given this advance in campaign planning, how would campaign planners choose between similar deployment plans? As assessment of competing sets of combat aircraft assets could be based upon campaign specific or theater specific issues that may not be addressed by an aircraft's absolute capability, but would be nonetheless important to the satisfactory completion of the operational missions required by that set of assets. Coupled with an assessment of the absolute capabilities of the combat aircraft comprising a particular set of assets, campaign planners can be provided a tool to study both the absolute and contextual suitability of an individual set of assets to a specific theater crisis.

The goals of this research were to assess the contribution of these contextual, campaign specific issues that could affect the operational capabilities or mission effectiveness of the combat aircraft within the particular set of assets, and to develop a decision support tool to measure these issues. To accomplish these goals, four questions were answered:

1. What factors other than absolute aircraft capabilities should campaign planners consider when selecting a specific set of combat aircraft to counter a theater threat?
2. How are these factors quantified?

3. What relationships link these factors to each other?
4. Based on a Southwest Asia scenario, what is the relative importance of each factor with respect to the others?

These questions were answered through a three-phase methodology shown in Table 2 of Chapter 3.

Phase I of the research was accomplished through a literature review of Joint and Air Force operational planning publications, and through Cognitive Task Analysis (CTA) interviews conducted with campaign planning staff members from Headquarters United States Air Force (USAF), Headquarters USAF Central Command (CENTAF), Air Combat Command, and Air University. The purpose of these interviews was to elicit their opinions and experience on contextual issues that are addressed when conducting crisis action planning. The results of the literature review and the CTA interviews led to the development of a hierarchy of campaign specific issues, satisfying the first research question.

Phase II of the research methodology consisted of a Value-Focused Thinking (VFT) interview with campaign planners from CENTAF. The purpose of the VFT interview was to obtain quantifiable ranges of measurements to measurable campaign specific issues within the context of a SWA Theater crisis. The result of the VFT interview led to the development of the Excel spreadsheet based decision support tool, satisfying the second research question.

Phase III of the research methodology consisted of an e-mail and interview Delphi study to obtain relative weights and relationships between the campaign specific issues identified in the value hierarchy. Campaign planners previously contacted for Phase I

and Phase II of the research were included in the Delphi study. The result of the Delphi study led to the development and confirmation of the relative weight of each campaign specific issue as they relate to the entire value hierarchy. These weights were incorporated into the decision support tool, resulting in an operational, value-focused asset set assessment tool. The results of the Delphi study answered the third and fourth research questions.

Finally, the campaign specific issue value model was analyzed based upon notional data developed for use within the Air Force Institute of Technology (AFIT)/ALP asset set optimization tool. This SWA Theater decision support tool can be incorporated into the AFIT/ALP optimization tool, providing a technique to assess the contextual issues that may affect the selection of a deployable set of combat aircraft.

CONCLUSIONS

COMBINATION OF COGNITIVE TASK ANALYSIS AND VALUE FOCUSED THINKING METHODOLOGIES

This research has shown that CTA and VFT methodologies can be synergistically combined, improving the viability of which a decision support tool can be developed and accepted. The CDM interviews were key to identifying the key campaign-specific issues which campaign planners must make decisions about when selecting combat aircraft to deploy in response to a theater crisis. These issues may be easily identified and addressed early on in the development of a campaign plan, by campaign planners with several years of experience. The VFT interviews integrated this information, assisting in the definition of measurement functions and identification of weighting between the campaign-specific issues. The combination of these two methodologies will assist less

experienced campaign planners in identifying and addressing these operationally endangering issues earlier on in the development of a campaign plan, and will help more experienced campaign planners to do a better job quicker and more efficiently the first time around.

DEVELOPMENT OF A CAMPAIGN-SPECIFIC ISSUE DECISION SUPPORT TOOL

It was possible to identify a set of campaign specific issues from Joint and Air Force publications and through CTA interviews with current Air Force campaign planners. From this set of issues, a value model was developed to study the affects of contextual issues on the selection of a set of combat aircraft to respond to a theater crisis. The model was designed to incorporate currently notional data from the AFIT/ALP asset set optimization tool, which will be used within the ALP computational architecture to improve the development of deployment plans.

LIMITATIONS

The focus of this research has been to examine the issues or factors not tied to the *absolute* capability of United States Air Force (USAF) combat aircraft to perform specific aerospace missions, that would affect the deployment suitability of particular aircraft assets to counter a theater threat. Because of this, the *absolute* capability of each individual USAF combat aircraft was not considered. Furthermore, campaign specific issues, not tied to the *absolute* capabilities of combat aircraft assets, may vary from theater to theater; therefore, this decision support tool research focuses only on the Southwest Asia (SWA) Theater. The Expeditionary Aerospace Force concept has been

developed to serve the SWA Theater. Therefore, the development of a decision support tool based upon the SWA theater can be most effectively applied by campaign planners within today's Concepts of Operations. However, the campaign specific issues identified in this research may be important in other theaters.

A further limitation of this research is the limited number of campaign planning experts contacted to participate in the CTA and VFT interviews and the Delphi study. Additional experts, amiable to the development of a campaign specific issue decision support tool would improve the understanding and support of this research.

RECOMMENDATIONS

It is recommended that this model be incorporated into the AFIT/ALP decision support tool for selecting deployable sets of combat aircraft. The addition of this model provides an avenue for the analysis of the effect of campaign specific issues on the value of combat aircraft.

A second recommendation from this research is with respect to the application of the Delphi study technique to elicit a consensus from a group of individuals. The viability of the Delphi study may have limited success with e-mail based surveys. It was seen in this research that questionnaires requiring a lengthy time commitment or extensive thought to complete may limit response rates, if those questionnaires are based on e-mail attachments. Questionnaires limited to the body of e-mail received a higher response rate due to their ease of use and readability. Future research considering the application of the Delphi methodology in an e-mail format should be wary of this limiting characteristic.

FUTURE RESEARCH

This effort should be expanded to other operational theaters and should be developed for overall USAF use. Expansion of the model will include the confirmation of the campaign specific issues identified in the value hierarchy with respect to all operational theaters. Relative weights of the issues within the value hierarchy must also be developed and tested for both different operational theaters and different deployment scenarios. It is believed that the relative weights of these campaign specific issues will undoubtedly change for different deployment scenarios, such as a humanitarian, peacekeeping, or show of force deployments.

Another potential research effort includes the development of real-world data to study comparable asset sets. The application of the contextual issue decision support tool to the AFIT/ALP asset set optimization tool is dependent upon the development of real-world information specific to combat aircraft and the campaign specific measures and constraints.

SUMMARY

The model developed for the Air Force Institute of Technology (AFIT)/Advanced Logistics Project (ALP) decision support tool provides a method to answer the question of how campaign specific issues can affect the selection of combat aircraft to deploy to the Southwest Asian Theater, consistent with Air Force values. The model was developed with the expert help of campaign planners from Headquarters USAF, Headquarters USAF Central Command, and Air Combat Command, as well as through current Air Force and Joint planning publications. The model was demonstrated by scoring 50 unique sets of assets identified within the AFIT/ALP Pilot Problem. This

work sets the foundation for further work and partnership between AFIT, ALP, and the Defense Advanced Research Projects Agency.

APPENDIX A: CTA Interview Bullet Background Paper Deployment Planning Factors

1. The purpose of this background paper is to provide the interviewee with an overview of discussion topics that will be addressed at this interview. The purpose of this interview is to obtain knowledge and understanding of the factors that influence the operational effectiveness of aircraft assets in deployed location

- Air Force has recently moved to the expeditionary concept.
 - Plan to deploy a small contingent of aircraft, 36 aircraft, 2 to 6 bomber assets
 - Forces may be expected to commence required aerospace missions immediately upon arrival.
 - Engaging enemy may require conducting several types of aerospace missions, defined in Air Force Doctrine 1-1.
- Important to look at inherent capabilities of aircraft assets when selecting specific types for deployment
- We look at more than just capabilities of individual aircraft assets when planning
 - Aspects of a deployment scenario may make selection of one aircraft type more preferred over another type, or may negate possibility of selecting certain types.
 - Identification and understanding of these aspects, or factors, is focus of today.
- Walk me through planning process for a expeditionary force contingency deployment
 - Understand several layers of planning and decision-making authority, but interested in your views at your level
 - In determining the proper aircraft assets to be deployed and planning for their deployment, what factors do you look at?
- Focus on identified factors
 - What makes these important?
 - Is there anything that may affect this factor...underlying sub-factors?
- Focus on sub-factors identified
 - What makes these important?
 - Is there anything that may affect this factor...underlying sub-factors?
- Continue break down of sub-factors until time no longer permits, or until interviewee has exhausted knowledge base.
- Conclusion to interview
 - Any other factors we have not identified that you feel are important, no matter level?
 - Any other topics you feel are important we did not discuss?
 - Any contacts you know of that I should talk to regarding this research?

- In a few weeks, I will begin second phase of research, and I would like to request your continued support
 - Second phase will consist of several e-mail questionnaires
 - Determine ranges of values and relative weights of importance for each factor identified and discussed today.
- Point of Contact for further discussion
 - 1Lt Christopher Buzo, Air Force Institute of Technology (AFIT)
(Christopher.Buzo@afit.af.mil)
 - Major Alan Johnson, AFIT (Alan.Johnson@afit.af.mil), DSN 255-3636 ext 4284
 - Major Steve Swartz, AFIT (Stephen.Swartz@afit.af.mil)
 - Advanced Logistics Project Website (www.darpa.mil/iso/alp)

APPENDIX B: CTA Interview Narrative

INTRODUCTION:

Good Afternoon and thank you for taking time out of your busy schedule to meet with me. As you may know, I am currently conducting research into the factors that influence the operational effectiveness of aircraft assets in a deployed location. The purpose of this interview with you is to elicit your knowledge and understanding of these factors.

The information I collect through this interview will be combined with that of others and reported in aggregate. Therefore, anything that is obtained through this interview is confidential. Other than my observers and myself, no other person will have access to any identifiable information.

Understanding this obligation of confidentiality, I would like to ask your permission to record this conversation. If at anytime you would like to stop recording for any reason, please just let me know. If you are interested, I would be glad to forward a copy of this interview to you after it is transcribed.

I have to apologize in advance for having to watch the clock and perhaps trying to push you ahead but I do not want to take up more than 45 minutes of your time and there are a number of things I would like to cover.

After saying that, I still want to stress that the interview is largely unstructured. However, if there is anything that you would like to discuss further with in the context of these issues, just let me know. Now, do you have any questions before we start?

BACKGROUND:

As we begin our discussion of influential factors, I would like to set the deployment stage. As you know, the Air Force has recently moved to the expeditionary concept. Under an Air Expeditionary deployment, we plan to deploy a small contingent of aircraft, generally 36 fighter aircraft, 2 to 6 bomber assets, and other necessary support aircraft. As you know, these forces may be expected to commence required aerospace missions immediately upon arrival. Engaging the enemy may require conducting several types of aerospace missions, as defined in Air Force Doctrine 1-1.

Research is currently being conducted in an effort to assist theater commanders and campaign planners in selecting sets of aircraft assets (mixes of fighters and bombers) that will provide the best "utility" to the commander, based upon the theater commander's aerospace mission requirements. Using the developed mathematical program, asset sets will be identified to provide the commander with the best "match-up" of aircraft assets to required missions. These match-ups are based upon the inherent capabilities of each individual aircraft asset to specific aerospace missions. Of course, we know that we look at more than just the capabilities of individual aircraft assets when planning a deployment. There are aspects of a deployment scenario that may make the selection of one aircraft type more preferred over another type, or may negate the possibility of selecting one or more types. The identification and understanding of these

aspects, or factors, is what I would like to focus on today. I am going to ask you a series of questions aimed at obtaining your views and insights into these deployment factors.

ILICITATION QUESTIONS:

1. I would like you to walk me through the planning process for a contingency deployment; one that would be suited to an expeditionary sized deployment. I understand that there are several layers of planning and decision-making authority within the planning process, but right now I am interested in your views at your level of the planning process. In determining the proper aircraft assets to be deployed, what factors do you look at?

- If answer(s) is/are not specific, reiterate question
- Continue to press for answers until interviewee appears to be out of responses

2. Are there any more details or factors, no matter how insignificant you may feel they are, that should be identified?

3. INSERT APPRECIATIVE REMARK. Now I would like to focus in on these factors that you have identified. If at any time you think of another factor that has not been previously identified, no matter how insignificant you feel it may be, please bring it up.

Looking at (EACH INDIVIDUAL IDENTIFIED FACTOR), what makes this factor important in the planning process? Is there anything that may affect this factor? Are there any underlying sub-factors?

4. It looks as though we have identified some very important factors in planning an expeditionary force deployment, and we have found several underlying sub-factors that can influence the decision. I would now like to focus on these sub-factors. Once again, if at any time you think of another factor that has not been previously identified, no matter how insignificant you feel it may be, please bring it up.

Looking at (EACH INDIVIDUAL IDENTIFIED SUB-FACTOR), what makes this sub-factor important in the planning process? Is there anything that may affect this sub-factor? Are there any underlying sub-factors?

5. I would like to continue this break down of sub-factors. Looking at.....

CONCLUSION:

6. It appears as though we have identified a number of important factors that must be considered when planning an expeditionary force deployment. Do you feel confident that we have exhausted this list? If not, are there any factors we have not identified that you feel are important? Was there anything that we did not talk about that seems relevant to this research? Are there any people or offices you know of that I should talk to regarding this research?

7. I would like to thank you very much for your time for this interview. In a few weeks, I will begin the second phase of this research, and I would like to request your continued support for this phase. The second phase of my research will consist of several e-mail questionnaires in which I will ask several planning experts (such as yourself) to determine ranges of values and relative weights of importance for each of these deployment planning factors. Again, it has been a pleasure to talk with you and I look forward to your continued support in this research effort.

APPENDIX C: VFT Study Dictionary of Campaign Specific Issues DEPLOYMENT PLANNING FACTOR DEFINITIONS

Title: Multi-National Compatibility

Description: Extent to which host-nation assets, to include combat aircraft, equipment, spares, and support equipment can be incorporated along side and into USAF combat aircraft.

Measurement: "Compatibility of Assets in Asset Set." 0 – 100 percent. At 100 percent compatibility, the staging base that the host nation maintains and operates like assets for 100 percent of the assets in the asset set. USAF combat aircraft can be incorporated into the staging base without bringing in testing equipment, spares, or excessive maintenance equipment. At 0 percent, all of the assets in the asset set are different (no like assets between United States Air Force combat aircraft and host nation combat aircraft). In this situation, campaign planners would need to bring a complete supply of testing equipment, spares, and maintenance and repair equipment for all combat aircraft brought into the staging base. The entire range of percentages of host-nation compatibility is possible.

Title: Beddown Location

Description: The effectiveness of an individual asset within the asset set is dependent upon the distance from the staging base to the target.

Measurement: "Distance (miles) From Target." 0 – 6000 miles. This measure scores the location of the staging base from the general enemy target area. Bomber and fighter assets have different distance abilities; therefore, each has a separate curve. Additionally, separate curves are required for refueled and un-refueled operations. It has been determined for this analysis that 6000 miles is the effective distance of bomber assets due to crew capabilities. The effective range of a fighter aircraft, determined for this analysis, is 2500 miles, due to crew capabilities. For each type of aircraft (fighter or bomber), the entire range of effective distances within their specific ranges is possible.

Title: Re-supply Ability

Description: Continued combat operations from the staging base are dependent upon the ability of USAF force's equipment and materials to be resupplied. Assuming the staging base has been predetermined, the selection of combat aircraft assets will be dependent upon individual asset's resupply requirements. Combat aircraft that require smaller amounts of POL, munitions, and other equipment will have a higher inherent value than an aircraft type that requires more assets.

Measurement: "Ratio of Resupply to Consumption to." 0 – 1. At the ratio of resupply to consumption increases to 1, US force's ability to resupply the staging base with required equipment and materials (i.e. munitions, aircraft replacement parts) for an aircraft asset is equal to the consumption of those same equipment and materials. As the ratio of resupply to consumption decreases to 0, combat aircraft consumption rates far exceed our force's ability to resupply the staging base. Ratios above 1 would not be experienced, as they imply assets are being shipped to the staging base location that are not needed. The entire range of ratios of resupply to consumption is possible.

Title: Munitions Storage: Fighter Assets

Description: Continued fighter operations depend heavily on the pre-determined staging base's ability to store specific munitions for fighter operations. Fighter aircraft can only bring one load of munitions; additional sorties require the ability of the staging base to re-load the fighter.

Measurement: "Fighter Sorties per Day." 0 – 100 percent. At 100 percent sortie rate per day, the staging base's munitions storage area (MSA), (includes storage and supply) can support 100 percent of the Commander in Chief's (CINCs) fighter sortie requirements per day. At 0 percent sortie rate per day, no sorties can be supported. While 0 percent is theoretically possible, 0 percent is not likely, because if the staging base could not store the required munitions for a particular fighter sortie, another aircraft alternative would be selected. At 50 percent sortie rate per day, only 50 percent of the sorties required of the particular aircraft asset can be conducted. The entire range of percentages of fighter sorties per day supported is possible.

Title: Munitions Storage: Bomber Assets

Description: Continued bomber operations depend on the pre-determined staging base's ability to store specific munitions for bomber operations. Bomber aircraft can only bring one load of munitions; additional sorties require the ability of the staging base to re-load the fighter.

Measurement: "Bomber Sorties per Day." 0 – 100 percent. At 100 percent sortie rate per day, the staging base's munitions storage area (MSA), (includes storage and supply) can support 100 percent of the Commander in Chief's (CINCs) bomber sortie requirements per day. At 0 percent sortie rate per day, no sorties can be supported. While 0 percent is theoretically possible, 0 percent is not likely, because if the staging base could not store the required munitions for a particular bomber sortie, the bomber aircraft would re-locate to another staging base or another aircraft alternative would be used. At 50 percent sortie rate per day, only 50 percent of the sorties required of the particular aircraft asset can be conducted. The entire range of percentages of bomber sorties per day supported is possible.

Title: Petroleum, Oil, and Lubricants (POL) Capability

Description: The staging base's POL system includes storage and supply from both military and host-nation contracted sources. POL capability for a particular asset set must take into consideration the per-sortie POL requirements of each individual aircraft in the asset set as well as the daily sortie requirements for each individual aircraft.

Measurement: "Mission Capability." 0 – 100 percent. At 100 percent mission capability, the staging base POL system can support 100 percent of the Commander in Chief's (CINC's) sortie requirements, whether the POL comes from on-base or off-base contracted sources. At 0 percent mission capability, no sorties can be supported. While 0 percent is theoretically possible, if 0 percent capability were experienced, aircraft assets would be directed to a different staging base. The entire range of percentages of mission capability due to POL storage and supply is possible.

Title: Tanker Support Required

Description: Depending upon the location of the staging base from the enemy target and the fuel requirements per aircraft asset sortie, and the number of aircraft assets conducting sorties at a particular time, multiple tanker assets may be required.

Measurement: "Tankers Required." 0 – 10. This measure scores the number of tankers required in the theater to support asset set sorties. Depending upon the fuel requirements for a particular aircraft asset and the distance between the staging base and enemy target, tanker assets may be required. Additionally, the intensity of combat in and around the enemy target may require tanker support. Note, this measure only counts tanker that are specifically dedicated to combat operations; cargo and intelligence gathering aircraft are not considered. This measure counts actual numbers of tankers required over the area of responsibility, and not tanker sorties. No tankers required (0) would be experienced if combat operations did not require aerial refueling. Ten tankers required (10) would be experienced if combat operations required an extensive amount of sustained aerial operations. The entire range of number of tankers required is possible, although 10 tankers required are a theoretical maximum.

Title: Topography

Description: The extent to which natural and man-made land formations around the pre-determined staging base effects the ability of individual aircraft assets within an asset set to take-off and land at the staging base.

Measurement: "Degradation of Mission." 0 – 100 percent. At 100 percent mission degradation, no sorties can fly in or out of the staging base due to topographical restrictions. 100 percent mission degradation, is a theoretical maximum, because if all aircraft assets could not take-off from the staging base with enough munitions to successfully accomplish the mission, those aircraft would be directed to a different staging base. At 0 percent mission degradation, all aircraft can fly sorties out of and return to the staging base with enough munitions and fuel to successfully complete the required aerospace missions. At 50 percent mission degradation, combat aircraft can fly into and out of the staging base at 50 percent capability. 50 percent capability is defined as an aircraft asset that can only be configured with enough fuel and munitions to achieve a 50 percent probability of kill over the enemy target. The entire range of percentages of degradation of mission due to staging base location topography is possible.

Title: Climate

Description: The extent to which heat, humidity, adverse wind and atmospheric pressure would affect the ability of particular aircraft assets to conduct combat operations.

Measurement: "Degradation of Mission." 0 – 100 percent. At 100 percent Mission Degradation, no sorties can fly. This is a theoretical maximum degradation of mission, because if, for instance, the cross winds at the staging base were such that a particular aircraft asset could not land, that aircraft asset would be directed to another base. At 0 percent Mission Degradation, all sorties (all aircraft) can fly at 100 percent capability. At 50 percent Mission Degradation, An aircraft asset can only take-off at 50 percent cll sorties (all aircraft) can fly at 50 percent capability (i.e. only 50 percent of maximum munitions loading for bombers). The entire range of percentages of mission degradation due to climate is possible

Title: Availability of Assets

Description: Extent to which aircraft assets in the asset set are operationally capable of being used to conduct aerospace missions required by the theater commander.

Measurement: "Average Mission Capable Rate of Assets in Set." 0 – 100 percent. At 100 percent average mission capable rate, all of the assets in the set of assets have a 100 percent mission capable rate. This would mean that maintenance and repair requirements for each individual aircraft in the asset set could be completed without reducing the Mission Capability rate. At 0 percent average mission capable rate, all assets in the set of assets are non-flyable. This should be a theoretical minimum, because under circumstances where all of the assets in the asset set were grounded due to maintenance, another set of aircraft would be chosen. At 50 percent average mission capable rate, some assets may have a mission capable rate higher than 50 percent, while some assets may have a mission capable rate less than 50 percent. The entire range of percentages of availability of assets is possible.

Title: Asset Mission Flexibility

Description: Extent to which the aircraft within the asset set can perform all of the possible aerospace missions defined in AFM 1-1 and AFDD 2-1. The relative worth of the asset set would be high if that asset set could perform any mission required by the theater commander.

Measurement: "Percent Capability of All Aerospace Missions." 0 – 100 percent. At 0 percent aerospace mission capability, the assets in the asset set cannot perform any aerospace combat mission required by the theater Commander in Chief (CINC). This is a theoretical minimum, as all aircraft assets are capable of performing at least one aerospace mission. At 100 percent aerospace mission capability, the assets in the asset set can perform any and all of the aerospace combat missions that could possibly be required by the theater CINC. 100 percent aerospace mission capability is achieved if the assets in the asset set can collectively perform all of the aerospace combat missions as defined in Air Force Manual 1-1 and Air Force Doctrine Document 2-1. The entire range of percentages of aerospace mission capability is possible.

Title: Asset Set Utilization

Description: Extent to which aircraft in the asset set is used to perform aerospace missions as required by the theater commander. This assumes that aircraft brought into the theater will be used to conduct combat sorties and are not brought in only as a show of force. If aircraft assets are brought in only as a show of force, this may or may not be an issue.

Measurement: "Use of Primary Aircraft Authorized." 0 – 70 percent. At 0 percent use of primary aircraft authorized, no assets in the asset set are being used. This is a theoretical minimum, because assuming the aircraft are not brought in only as a show of force, the aircraft should be used for at least pilot training. At 70 percent use of primary aircraft authorized, all of the assets in the asset set are being used to their peak operationally safe use. 100 percent use of primary aircraft authorized is defined as the continual "turn and burn" of all aircraft assets at the staging base. Aircraft would be at the staging base only long enough to reload munitions and change pilots, if necessary. 70 percent has been determined to be the maximum rate an aircraft asset can be safely used before the long-term operational capability is jeopardized. The entire range of percentages of use of primary aircraft authorized is possible.

Title: Asset Set Over-Utilization

Description: Extent to which aircraft in the asset set is over-used to perform aerospace missions as required by the theater commander. This assumes that aircraft brought into the theater are being used beyond their operationally safe limit. This measure is an extension of the *Asset Set Utilization* measure whereby aircraft assets are being used beyond the measure's range.

Measurement: "Use of Primary Aircraft Authorized." 70 – 100 percent. At 70 percent use of primary aircraft authorized, all assets in asset set are being used to their peak operational efficiency. This could be experienced during an initial surge of sortie activity, where USAF combat aircraft have been tasked to halt enemy action. At 100 percent used of primary aircraft authorized, aircraft in asset set have been surged to theoretical maximum, whereby all of the aircraft in the asset set are in a state of continual "turn and burn." 100 percent use of primary aircraft authorized cannot be sustained, as it will quickly degrade the capability of the aircraft assets to perform the mission. The entire range of percentages of use of primary aircraft authorized is possible.

Title: Enemy Ability and Capabilities versus Asset Set

Description: This factor measures the comparison of enemy assets to USAF combat aircraft assets. Assuming US intelligence can determine the extent of the enemy's capability, this measure shows the relative worth of the amount of aircraft assets brought into the pre-determined staging base. One issue of this measure is the number of USAF combat aircraft brought into the staging base; another issue is the capabilities of the enemy to counter the USAF combat aircraft brought into the staging base.

Measurement: "Ratio of Allied to Enemy Forces." 0 – 3. As the ratio of Allied to Enemy Forces approaches 0, the enemy's ability and capability versus the combined capabilities of the combat aircraft assets in the asset set is continuing to increase. This means that the capabilities of the enemy exceed USAF combat aircraft capabilities. For example, the capability of a single enemy MIG may have the same capabilities as 3 US F-15s. As the ratio of Allied to Enemy Forces approaches 1, the capability of enemy forces and USAF combat aircraft is equal. For example, the capability of a single enemy MIG may have the same capabilities as one US F-16. As the ratio of Allied to Enemy Forces approaches 3, the capabilities of USAF combat aircraft outweighs the capability of enemy forces by 300 percent. For example, the capability of three enemy MIGs may have the same capabilities as a single F-117. The entire range of ratios is possible, and while the ratio of USAF combat aircraft to Enemy forces may exceed 3, no additional value is obtained. Note: this is a capabilities based measure that requires intelligence on the capabilities and number of the enemy's forces in relation to the USAF combat aircraft within a particular asset set.

Title: Enemy Intelligence, Surveillance, and Reconnaissance (ISR)

Description: This measure captures the enemy's ability to see or obtain information on US activity at the pre-determined staging base. Enemy ISR could be obtained through aerial or satellite photography, local sympathizers monitoring US activity, or spies within the host-nation working within or around the staging base.

Measurement: "Activity Exposure." 0 – 100 percent. At 0 percent exposure, the enemy has no intelligence on or ability to see our operations. This may occur due to the enemy's lack of ISR capabilities or due to strict secrecy of operational activity at the staging base. At 100 percent exposure, the enemy has full knowledge or visibility of our operations. 100 percent exposure is more conceivable than 0 percent exposure, as the presence of US combat aircraft at a staging base not usually hosting US forces would arouse some suspicion and concern of enemy leadership. The entire range of percentages of activity exposure is possible, due to the capabilities of the enemy and the amount of local sympathy for the enemy.

Title: Enemy Interference

Description: This measure captures the enemy's ability to interfere with US operations at the pre-determined staging base. Enemy interference is any action on the part of the enemy that would hamper US combat operations. Enemy interference could range from picketing and loitering around the staging base, isolated attempts to gain access into the base and base operations, bomb threats, attacks on aircraft taking off and landing at the base, or attacks on the base itself.

Measurement: "Operation degradation." 0 – 100 percent. At 0 percent operation degradation, no enemy interference of any kind is experienced at the staging base. At 100 percent operation degradation, enemy interference has halted any and all combat operations, to include destruction of the staging base. 100 percent operation degradation is a theoretical maximum, because if an actual attack on the staging base were expected to occur, the aircraft would be re-located to a different staging base. The entire range of percentages of operation degradation is possible.

APPENDIX D: Campaign Specific Issue Graphs

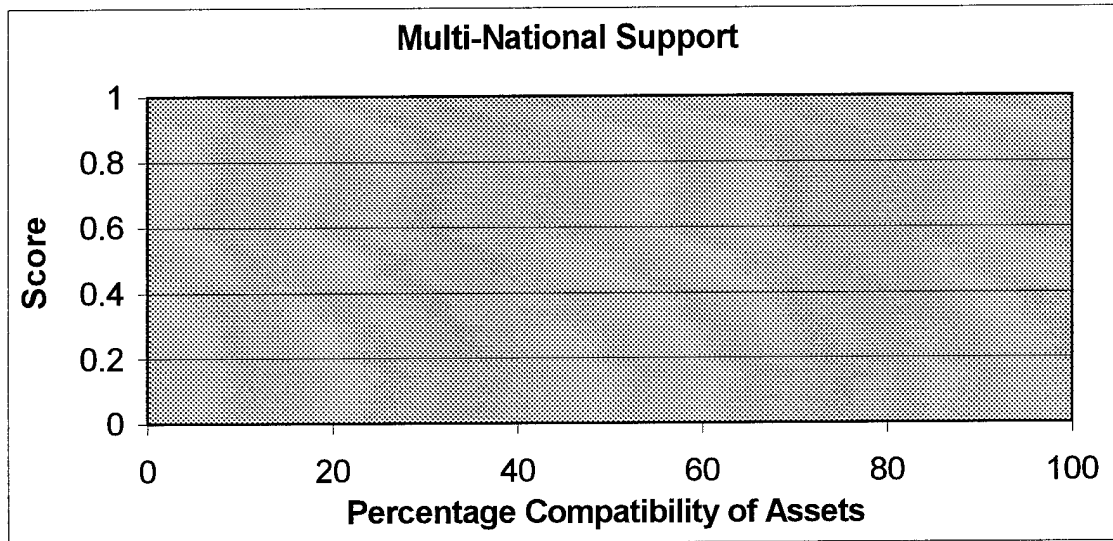


FIGURE 12: Multi-National Support Value Graph

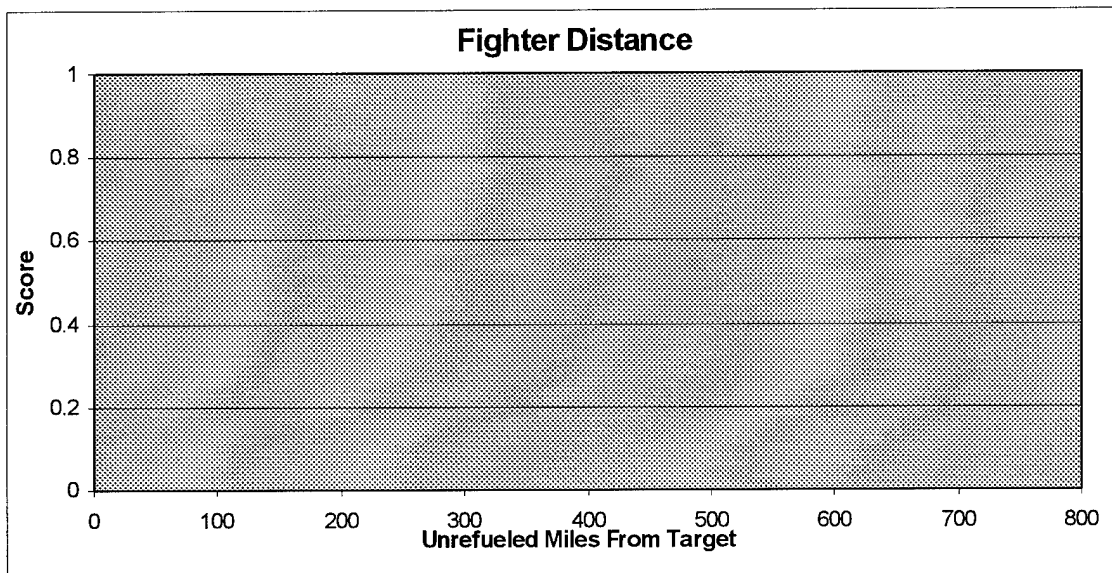


FIGURE 13: Beddown Location – Fighter Distance Value Graph

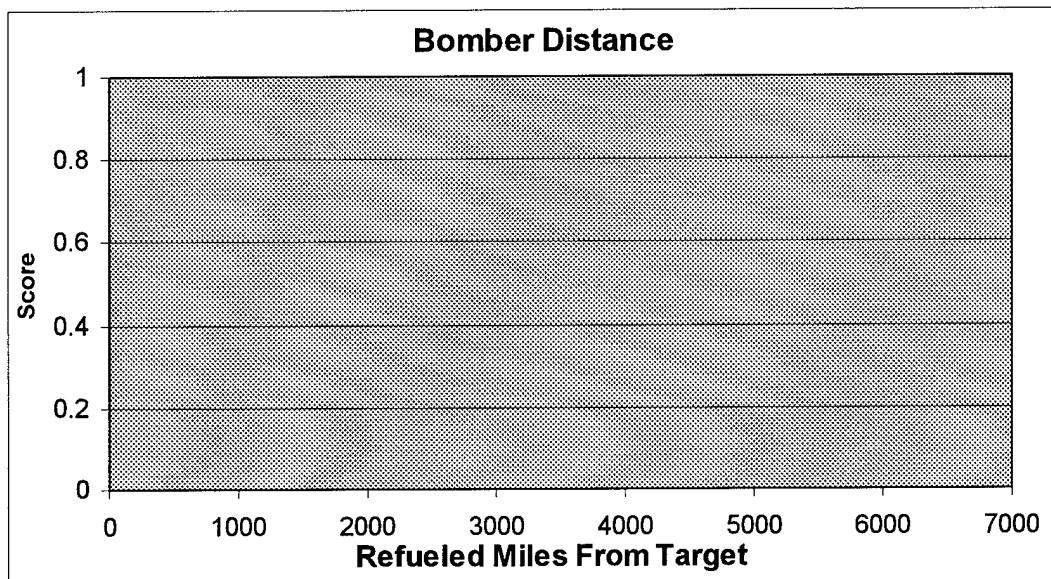


FIGURE 14: Beddown Location – Bomber Distance Value Graph

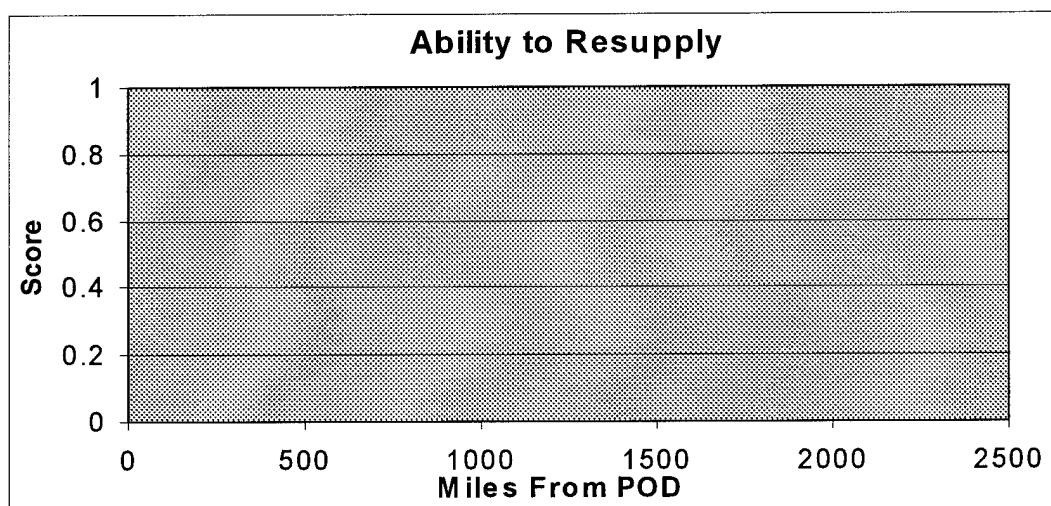


FIGURE 15: Resupply Location Value Graph

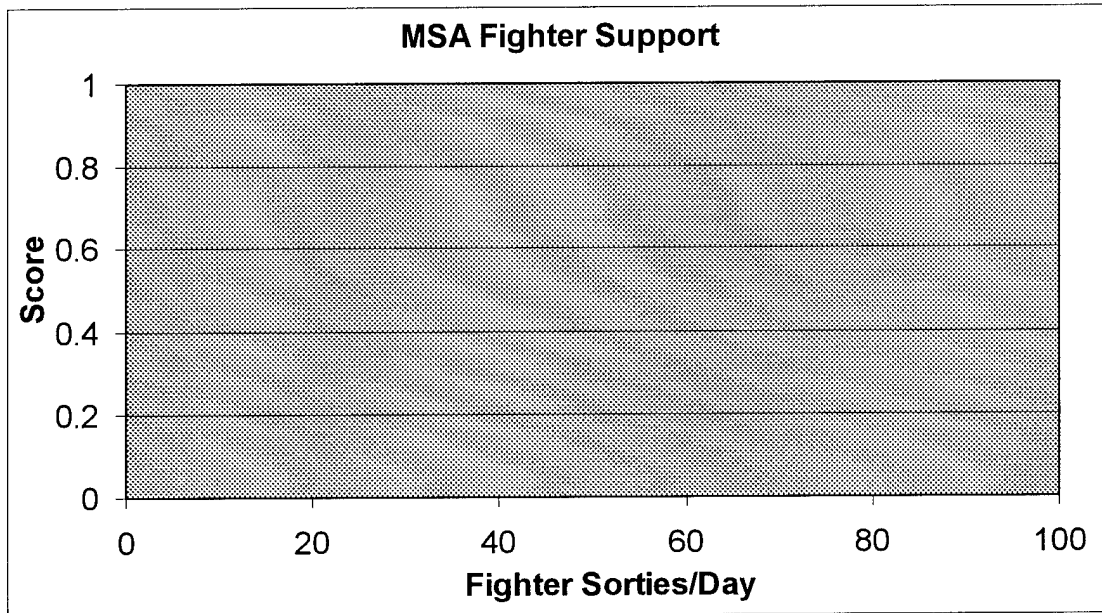


FIGURE 16: Munitions Storage Area – Fighter Support Value Graph

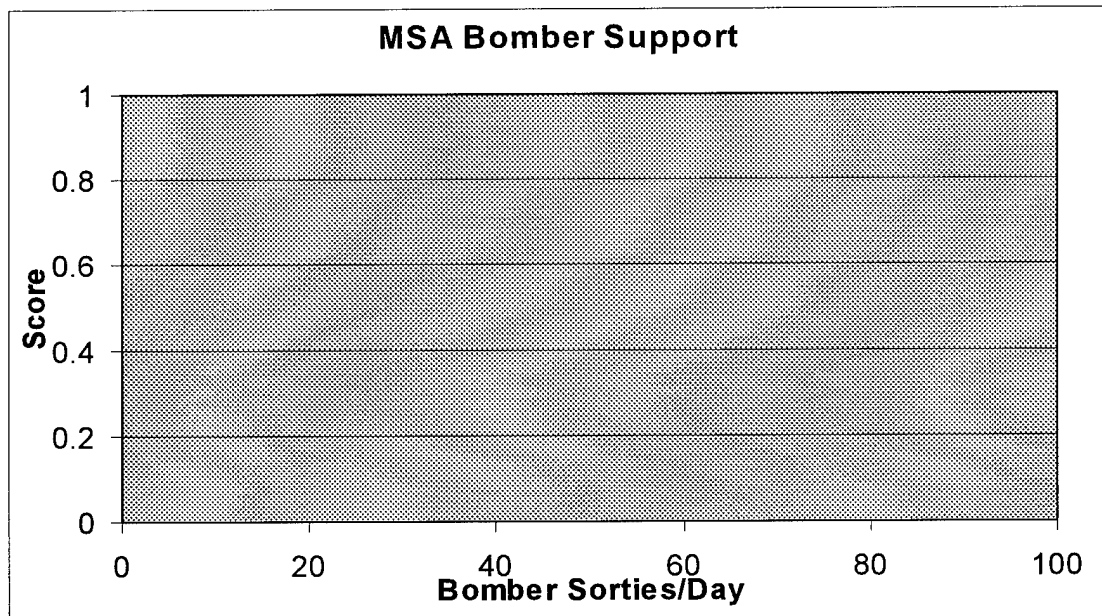


FIGURE 17: Munitions Storage Area – Bomber Support Value Graph

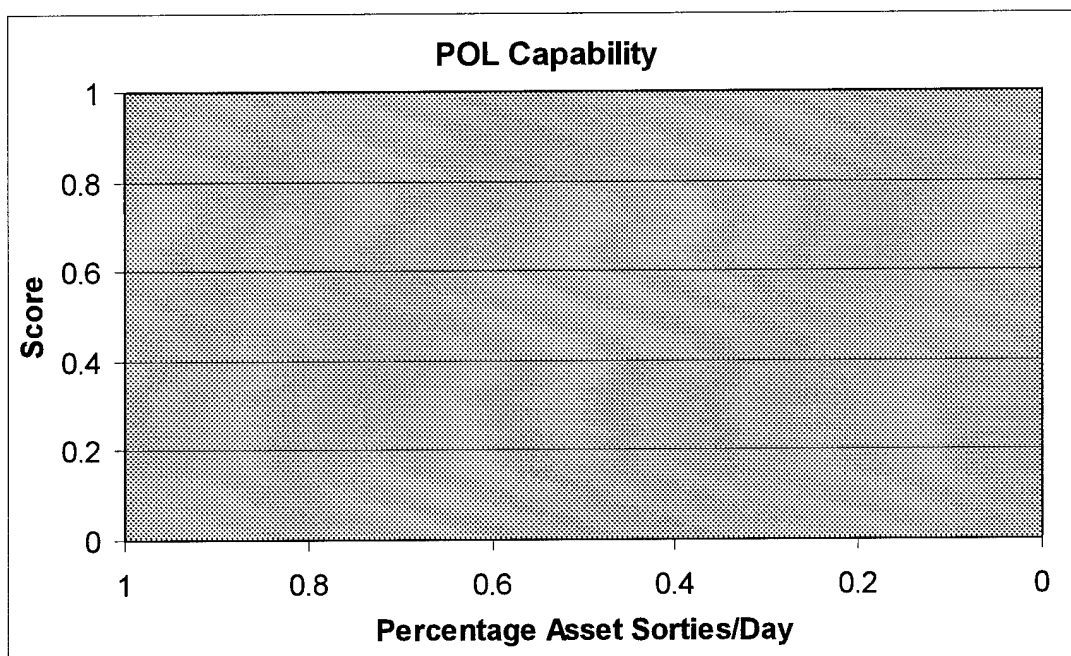


FIGURE 18: Petroleum, Oils, and Lubricants Capability Value Graph

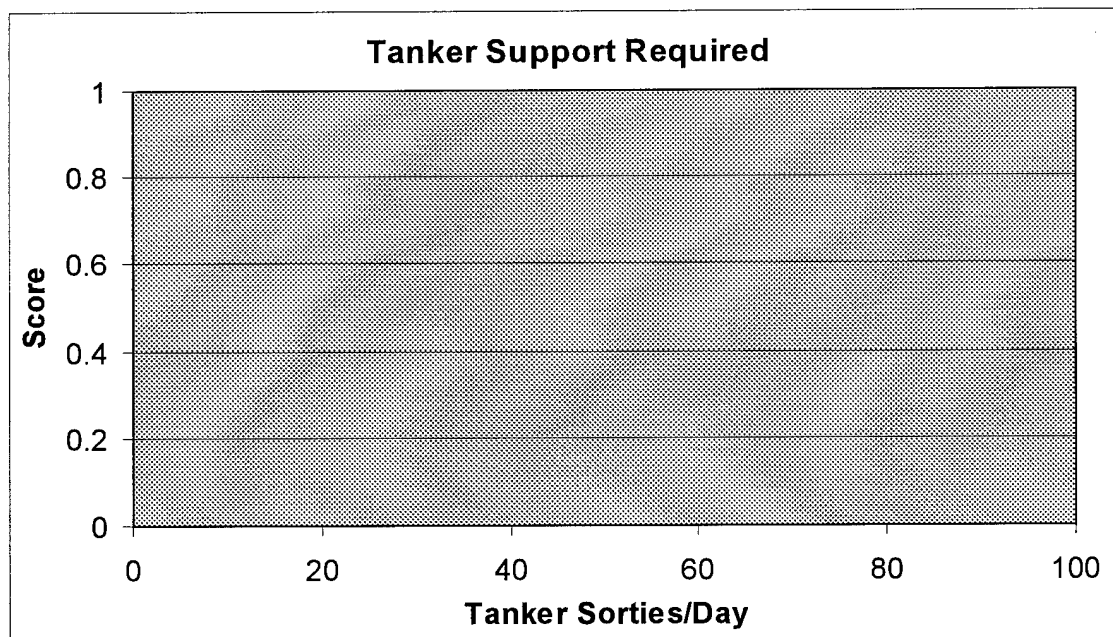


FIGURE 19: Tanker Support Required Value Graph

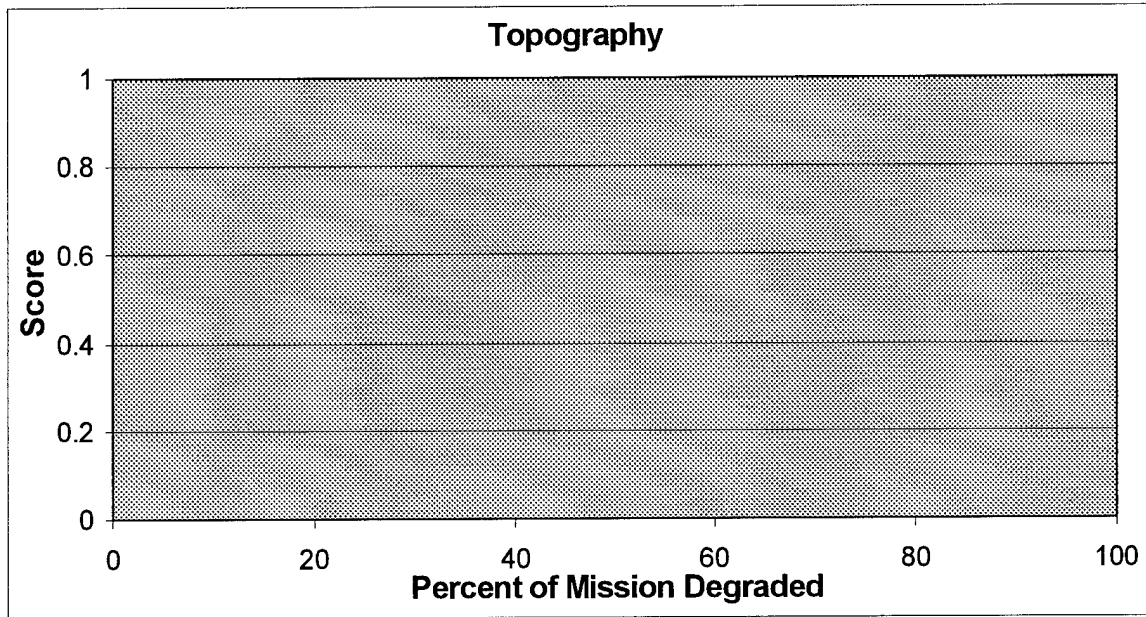


FIGURE 20: Topography Value Graph

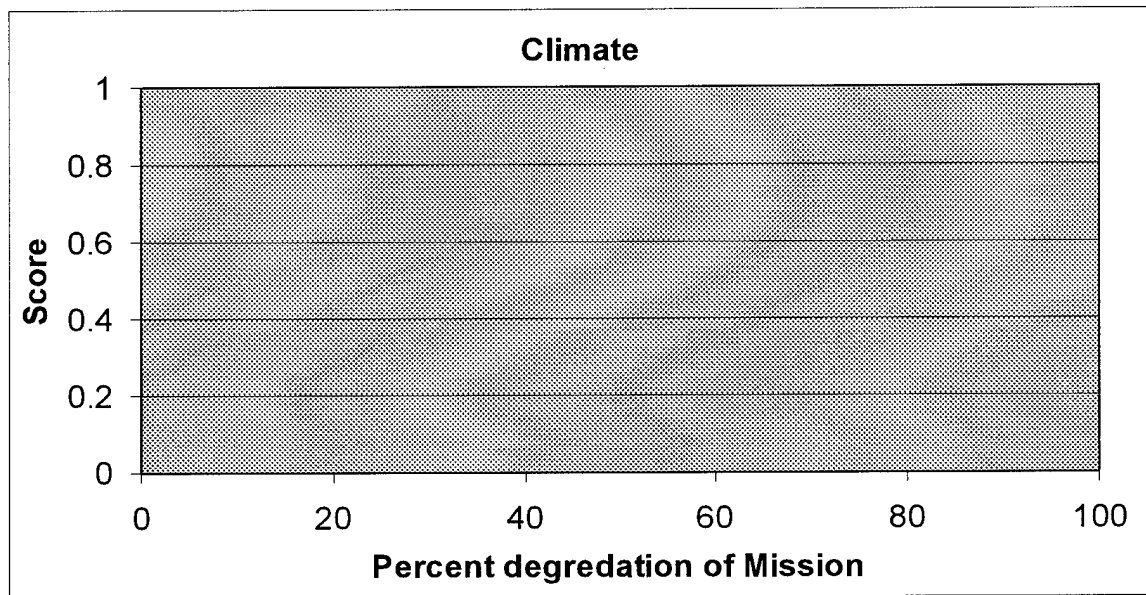


FIGURE 21: Climate Value Graph

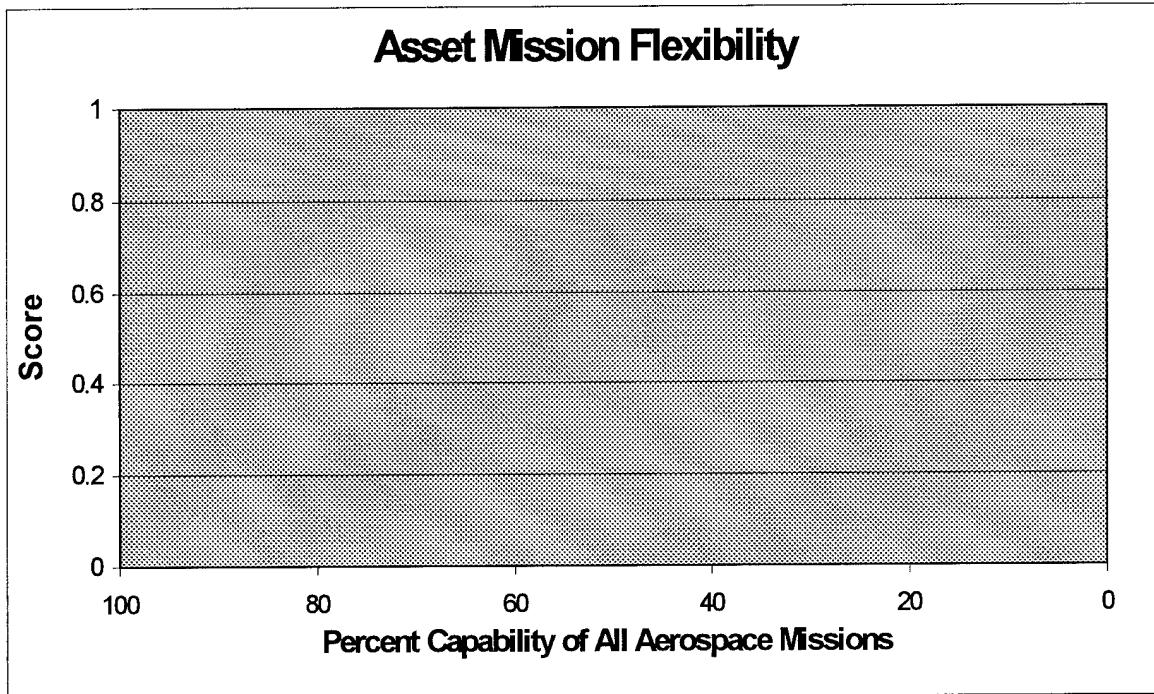


FIGURE 22: Asset Mission Flexibility Value Graph

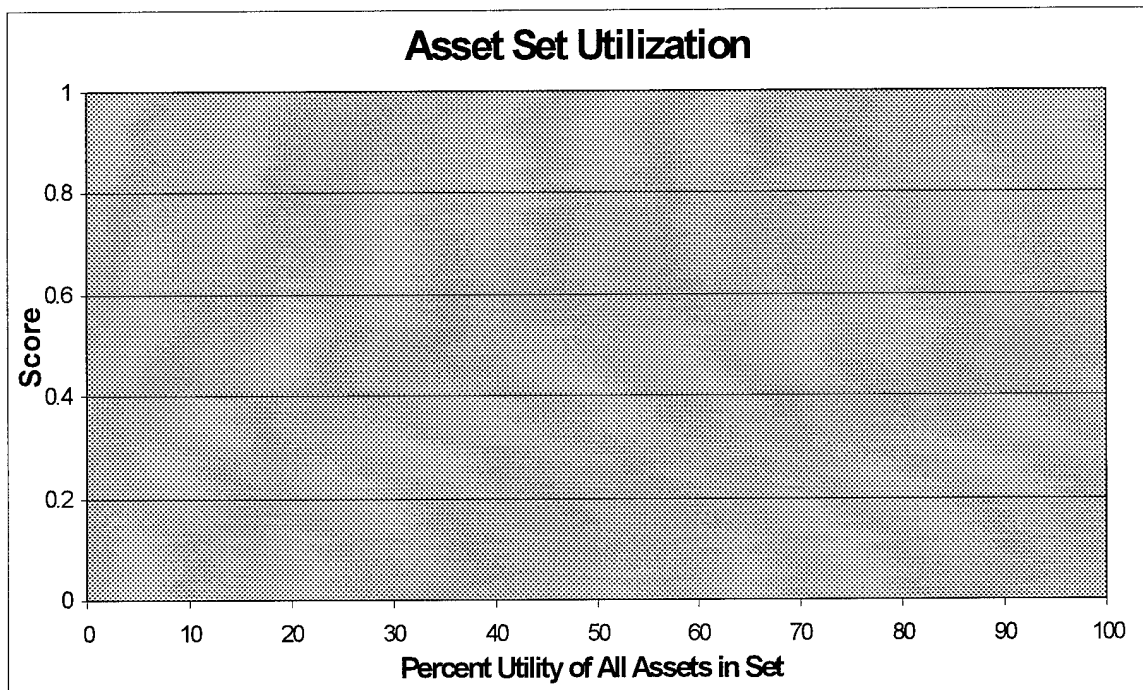


FIGURE 23: Asset Set Utilization Value Graph

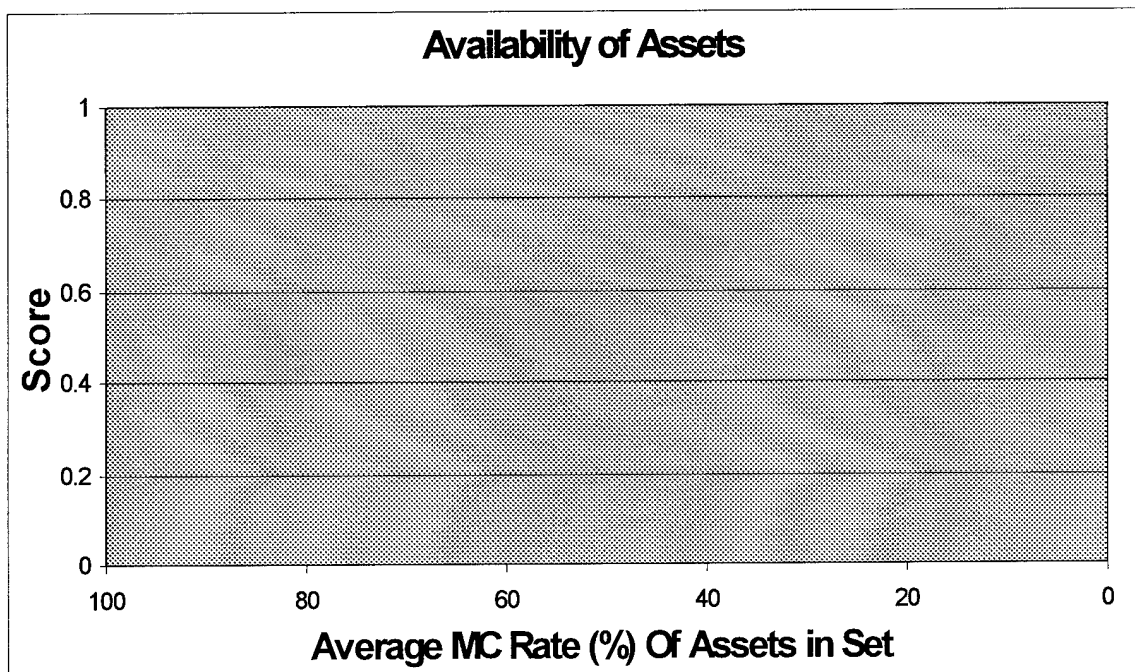


FIGURE 24: Availability of Assets Value Graph

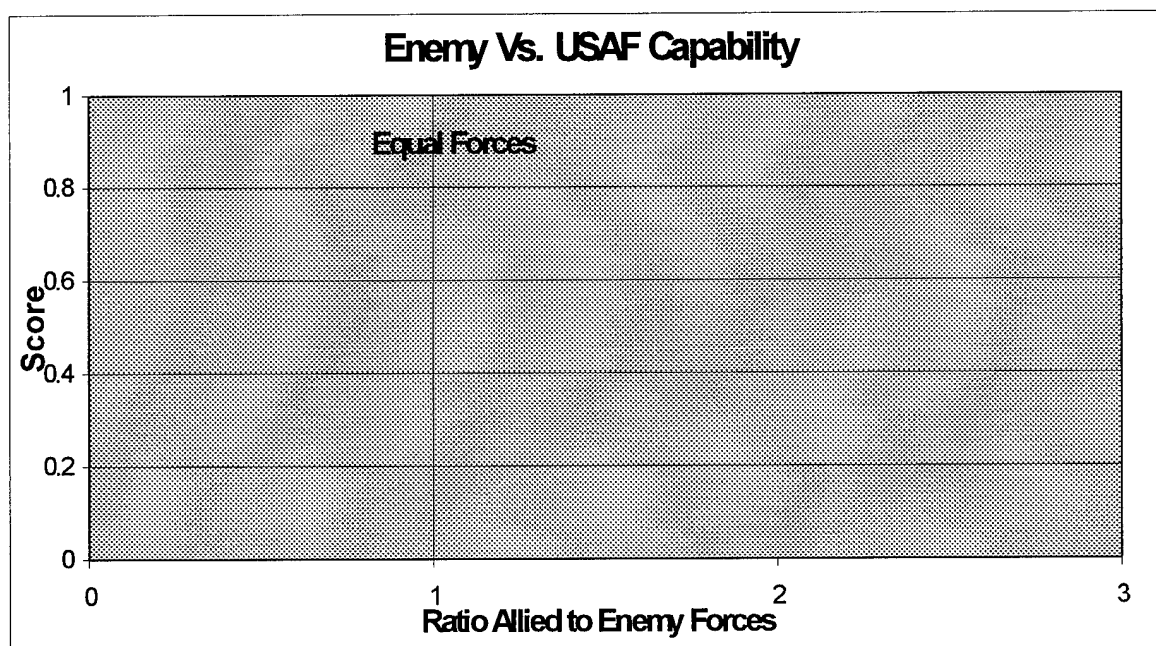


FIGURE 25: Enemy Vs. USAF Capability Value Graph

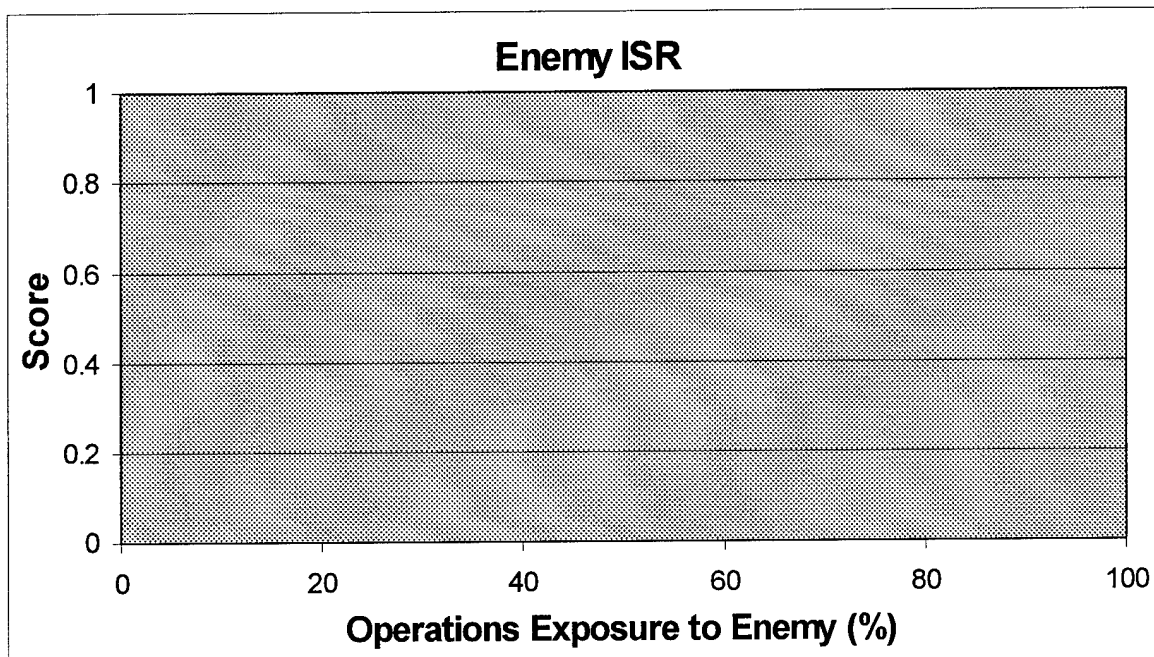


FIGURE 26: Enemy ISR Value Graph

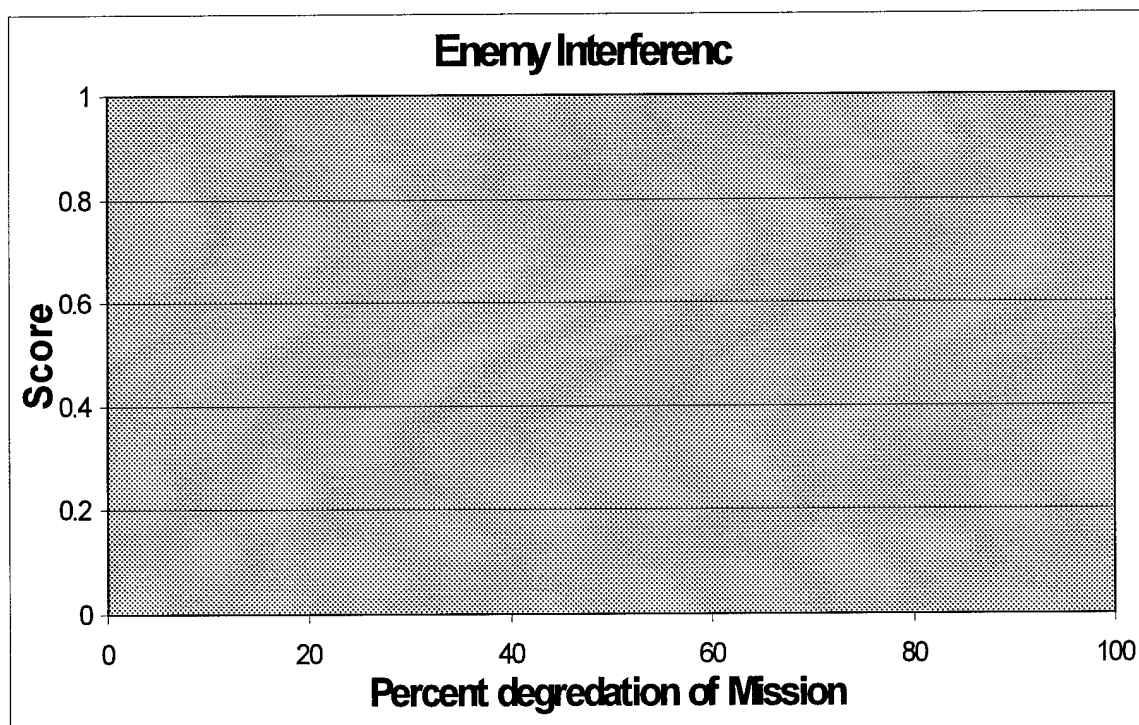
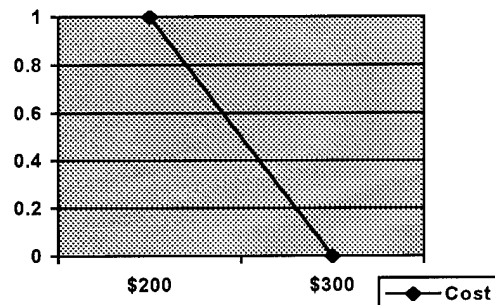


FIGURE 27: Enemy Interference Value Graph

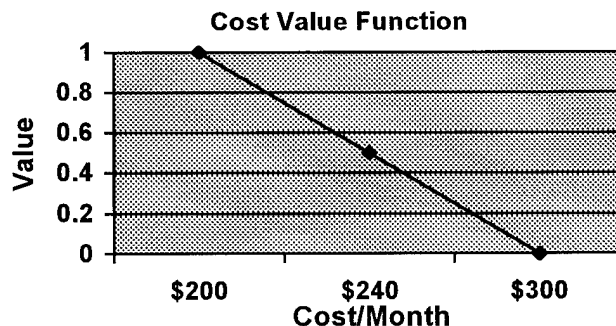
APPENDIX E: VFT Methodology Example

Say, for example, that you are interested in purchasing a new four-door, family size car. There are, of course, many styles and brands to choose from, each having many different features. You do, however, have three different cars that you would consider purchasing, but since you do not really have a clear favorite between these three, choosing the best vehicle seems a bit overwhelming. The first thing we need to do, therefore, is sit down and make a list of requirements. You know you can afford up to \$300 a month in car payments, but of course, the less you have to spend the better off you will be. You want good gas mileage, the higher the better. Air-Conditioning and Anti-Lock breaks would be nice to have. You have now created a list of factors, which you will use to guide your car-buying decision.

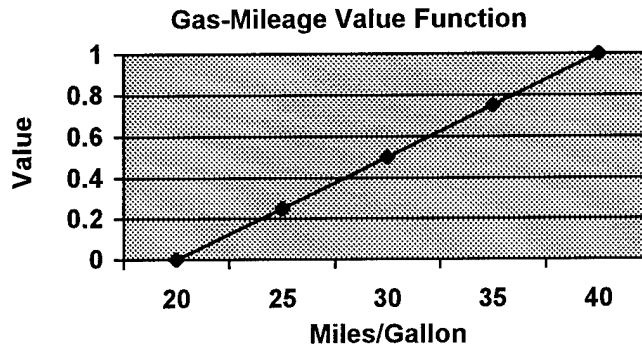
Now we need to develop quantitative ranges of values for each of the factors. You already know that you can only pay up to \$300 a month for your new car. Any car with a price above that you cannot afford. This, then, is your high value for cost. You then decide that you would be happiest if you could only pay \$200 a month for your new car. You would not really be any happier paying less than \$200, but you would be less happy if you had to pay more. We can now begin to graph your financial requirements for your new car.



After some thought, you realize that if the cost of your potential new car was, say, \$240, your “level of happiness” would be 50-percent. You now have a value function for the cost of your new car, with values ranging from 0 (you would have to pay \$300/month for your new car) to 1 (you could pay only \$200/month for your new car).



Now you need to do the same value analysis for each of your remaining factors: Gas-mileage, air-conditioning, and anti-lock breaks. After careful thought, you've developed your gas-mileage function as follows:



You note that the air-conditioning and anti-lock break factors cannot really be graphed the same way that cost and mileage were. Either the car in question has anti-lock breaks, or it does not. The same goes for the A/C. Therefore, you assign a value of 1 to the anti-lock break factor if the car does have anti-lock brakes and a value of 0 if the car does not have anti-lock brakes. The same value function is developed for A/C. If the car has A/C, the factor is assigned a value of 1; if not, the factor is assigned a value of 0.

Now that you have your value functions for each of your factors, you need to weight the individual value functions. Are you equally concerned about each of the factors you determined were important? Probably not. If you are like me, you are probably more concerned about cost than any of the other factors. For this example, say that you are three-times as concerned about the cost of the car as you are about its gas-mileage. You believe that having anti-lock breaks is twice as important as getting good gas-mileage, and that good gas-mileage and air-conditioning are equally important. We can now put this into quantitative numbers, because your weights must add up to 1 (100-percent). Here's the mathematics to this:

$$\begin{aligned} \text{Cost} &= 3 \times \text{Gas} \\ \text{Gas} &= \text{AC} \\ \text{Breaks} &= 2 \times \text{Gas} \end{aligned}$$

$$\text{Cost} + \text{Gas} + \text{AC} + \text{Breaks} = 1 \text{ (this must be true) Therefore...}$$

$$(3 \times \text{Gas}) + \text{Gas} + \text{Gas} + (2 \times \text{Gas}) = 1$$

$$\text{Gas} = 1/7$$

Therefore, Gas = 1/7, Cost = 3/7, AC = 1/7, and Breaks = 2/7. You have now weighted the importance of each one of your factors with respect to each other. Now comes the time for some research. You pick up the latest edition of the Car Trader and read up on the three cars you have your eye on. You write down the figures relevant to

your factors for each car. For this example, let's assume that the interest rates and repayment lengths are equal.

	Car A	Car B	Car C
Cost/Month	\$200	\$250	\$300
Gas-Mileage	30 MPG	25 MPG	30 MPG
Anti-Lock Breaks?	No	Yes	Yes
A/C?	No	No	Yes

Now it is time to put the figures from your research into your value functions. Compare each of the figures for each car to their respective value functions. For example, the value function developed for cost states that \$200/month has a value of 1, and \$300/month has a value of 0. We can match the car figures to our value-functions and develop a new chart.

	Car A	Car B	Car C
Cost/Month	1.0	0.5	0
Gas-Mileage	0.50	0.25	0.50
Anti-Lock Breaks?	0	1.0	1.0
A/C?	0	0	1.0

Now let's add the weighting of importance to each of the factors in the same chart.

	Weights	Car A	Car B	Car C
Cost/Month	3/7	1.0	0.5	0
Gas-Mileage	1/7	0.50	0.25	0.50
Anti-Lock Breaks?	2/7	0	1.0	1.0
A/C?	1/7	0	0	1.0

Now that we have all the numbers we need, we can determine the value of Cars A, B, and C by multiplying each factor value by its weight and sum these numbers. Using Car A as the example,

$$(3/7)*1.0 + (1/7)*0.50 + (2/7)*0 + (1/7)*0 = 0.50 \text{ -- Value of Car A.}$$

We can sum up the individual factor values for each car to get the value of each car:

Car A = 0.50
 Car B = 0.53
 Car C = 0.50

Therefore, you have determined Car B is the best car for you, because it has the highest value compared to the other 2 alternatives. You have made this decision based upon:

- The factors you determined were important in your new car
- The range of figures that each factor could have and their corresponding value
- The weighting of importance for each factor, and
- The 3 cars available to choose from.

APPENDIX F: DELPHI Study Questionnaire One

INSTRUCTIONS

*Please answer all questions on this document and return within an e-mail to:
Chrisotopher.Buzo@afit.af.mil*

1. Identification: Personal information WILL NOT be used during the Delphi process itself, nor will your comments be specifically linked to you in my thesis. However, your identification is relevant to the research effort and will be included in the thesis.

Name/Rank:

Position:

Office:

2. Please note that your participation and meaningful responses are fundamental to the success of this research. No thought or opinion is too trivial to not be included. What you believe is an insignificant comment might trigger a response in one of the other participants in the next round of questions.

3. Background: prior research has produced a decision support tool that relates a theater commander's mission needs with combat aircraft (asset sets) and their associated deployment footprints. The output of this tool is shown as the yellow box in Figure 1. However, integrating the presence and effect of campaign specific issues can improve the tool. The goal of this research is to identify and develop quantitative measures for campaign specific issues. Figure 1 presents a hierarchy of campaign specific issues, previously developed through discussion and interviews with you.

Campaign Issues

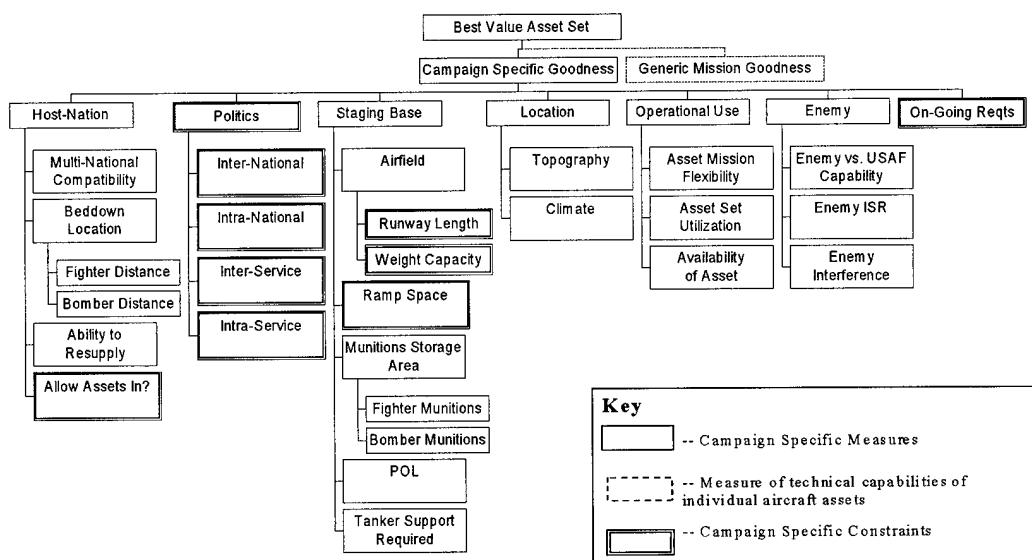


Figure 1: Campaign Specific Issues Hierarchy.

CAMPAIGN SPECIFIC ISSUES QUESTIONNAIRE ROUND 1

CAMPAIGN SPECIFIC ISSUES VERIFICATION AND PRIORITIZATION

Please refer to the Campaign Issue Hierarchy depicted in Figure 1. To help you understand how each issue is defined, we've included a "**Definitions**" email attachment that provides a description of each issue. Each issue's definition states what the issue covers, as well as how the issue is quantitatively measured.

The top-level box is labeled "Best Value Asset Set." Possible sets of fighter and bomber aircraft will be analyzed with respect to both campaign specific issues and technical capabilities. Campaign specific issues (green solid line boxes) and Campaign specific constraints (red double line boxes) are evaluated under the "Campaign Specific Goodness". Depending upon the particular set of combat aircraft assets, the measures can display a range of value or "worth" to the theater commander, while the constraints either permit or deny the use of a particular asset. **The technical capabilities of each combat aircraft with respect to aerospace missions are evaluated under the "Generic Mission Goodness" measure (yellow dashed line box). This measure is outside the realm of this study.** Based upon the information obtained from this decision support tool, campaign planners and theater commander can make more informed decisions in a shorter period of time.

There are two purposes or sections to this phase of the Delphi study:

- Confirm the campaign specific issues hierarchy (Question A)
- Order the issues according to their potential influence on the selection of aircraft assets. (Question B)

QUESTION A: Based upon your experience, is the hierarchy presented in Figure 1 correct? (Have we captured the right issues, in the right respective relationships?)

PLEASE ANSWER 'QUESTION A' HERE:

QUESTION B: Based upon your experience, please rank the campaign specific issues (1 through 24, where 1 is most important), shown in Figure 1, according to the potential influence their individual range of measurement could have upon the selection of a set of combat aircraft. Each measure and constraint is presented in bold font. Underneath the measure is the range of scores to which a unique aircraft asset set is measured. To the right is an underlined blank for your answer. Please type your numbered responses in the blank next to each issue. Please refer to the "Campaign Specific Issues Definition" document that accompanied this survey for questions on issue definitions.

For example, if you believe that *Climate*, the effects of which are measured as 0 – 100 percent mission degradation, is the most potentially influential issue in selecting a set of combat aircraft, you would place a '1' next to *Climate*. The next most potentially influential issue will receive a '2', and so forth.

CAMPAIGN SPECIFIC ISSUE AND MEASUREMENT

RANK

Multi-National Compatibility:

Compatibility of host-nation and US aircraft assets (0 – 100 percent)

Beddown Location: Fighter Distance

Pre-determined staging base distance to enemy target (0 – 3000 miles)

Beddown Location: Bomber Distance

Pre-determined staging base distance to enemy target (0 – 6500 miles)

Ability to Resupply

Ratio of Consumption to Resupply (0 to 1)

Allow Assets In

Yes or No constraint

Inter-national Politics

Yes or No constraint

Intra-national Politics

Yes or No constraint

Inter-service Politics

Yes or No constraint

Intra-service Politics

Yes or No constraint

Airfield: Runway Length

Yes or No constraint

Airfield: Weight Capacity

Yes or No constraint

QUESTION B Continued:

CAMPAIGN SPECIFIC ISSUE AND MEASUREMENT

RANK

Ramp Space

Yes or No constraint

Munitions Storage Area: Fighter Munitions

Percent of fighter sorties supported per day (0 – 100 percent)

Munitions Storage Area: Bomber Munitions

Percent of bomber sorties supported per day (0 – 100 percent)

Petroleum, Oil, and Lubricants (POL)

Percent of asset sorties supported per day (0 – 100 percent)

Tanker Support Required

Tankers required per day (0 – 35 tankers)

Topography

Percent degradation of mission (0 – 100 percent)

Climate

Percent degradation of mission (0 – 100 percent)

Asset Mission Flexibility

Percent capability of all aerospace missions (0 – 100 percent)

Asset Set Utilization

Average utility of all aircraft in asset set (0 – 70 percent average utility)

Asset Set Over-utilization

Average over-utility of all aircraft in asset set (70 – 100 percent average utility)

Availability of Asset

Average mission capable rate of aircraft in asset set (0 – 100 percent)

Enemy vs. USAF Capability

Ratio of Enemy to Allied Forces (0 to 3)

Enemy Intelligence, Surveillance, and Reconnaissance

Percent of operations exposure to enemy (0 – 100 percent)

Enemy Interference

Percent degradation of mission (0 – 100 percent)

On-Going Requirements

Yes or No constraint

This concludes this questionnaire. As you return the questionnaire, I will compile the answers given, and respond to you with a second round to the study. Within this round, any comments provided by you within Question A of the first round will be included. The relative rankings of each campaign specific issue will be presented according to the consensus or average of rankings received by you. If there are any extreme differences of opinion (i.e. the *Climate* issue was ranked second by one individual and twenty-second by another), these differences will be addressed. Thank you very much for your time and participation in this survey!

APPENDIX G: DELPHI Study Questionnaire Three

Campaign Specific Issues Delphi Questionnaire Three

*Please answer all questions on this document and return within an e-mail to:
Chrisotopher.Buzo@afit.af.mil*

The Purpose of this questionnaire is to determine relative weightings:

- Between the sub-issues within a parent issue (i.e. Multi-National Compatibility, Allow Assets In, etc. within Host Nation)
- Between parent issues (i.e. Host Nation, Enemy, etc)

During previous questionnaires, the relative rankings of importance between the campaign specific issues have been determined. Based upon these results, issues recognized to be more potentially influential will be ranked against those issues not as potentially influential to the selection of combat aircraft to deploy in response to a contingency crisis in the Southwest Asian Theater.

Please compare the Campaign Specific Issue in 'Column A' to the Campaign Specific Issue in 'Column B'. In each case, the issue in 'Column A' has been identified to be more potentially important than the issue in 'Column B'. Looking at the range of measurement for each issue, PLEASE STATE HOW MANY TIMES MORE IMPORTANT THE SWING FROM BEST SCORE TO WORST SCORE FOR THE ISSUE IN COLUMN 'A' IS THAN THE SWING FROM BEST SCORE TO WORST SCORE FOR THE ISSUE IN COLUMN 'B'.

Consider this example. Compare Petroleum, Oil and Lubricants (POL) to Beddown Location: Fighter Distance. The swing from best to worst score for POL is 100 percent to 0 percent support of asset sorties per day. The swing from best to worst score for Beddown Location: Fighter Distance is 0mi to 3000mi distance from the pre-determined staging base to the enemy target. I believe that, if POL were to drop from 100 percent to 0 percent, this drop would be 4 times worse than if Beddown Location:Fighter Distance were to increase from 0 mi to 3000 mi from the enemy target. As my answer, I put 4 in the middle block.

COLUMN A	IS HOW TIMES MORE IMPORTANT THAN	COLUMN B
Ex: Petroleum, Oil, Lubricants (100% to 0% asset sets supported per day)	4	Beddown Location: Fighter Distance (0mi to 3000mi distance to enemy target)

Based upon this example, please provide your answer to the following comparisons. If you feel that the issue in 'Column A' is less important than the issue in 'Column B', please use fractions (1/2, 1/3, etc.)

QUESTIONNAIRE 3 ANSWER SHEET

COLUMN A	IS HOW TIMES MORE IMPORTANT THAN	COLUMN B
Petroleum, Oil, Lubricants (100% to 0% asset sets supported per day)		Beddown Location: Fighter Distance (0mi to 3000mi distance to enemy target)
Enemy Vs. USAF Capability (3 to 0 USAF to Enemy Ratio)		Petroleum, Oil, Lubricants (100% to 0% asset sets supported per day)
Enemy Vs. USAF Capability (3 to 0 USAF to Enemy Ratio)		Availability of Asset (100% to 0% average mission capable rate of aircraft)
Availability of Asset (100% to 0% average mission capable rate of aircraft)		Multi-National Capability (100% to 0% compatibility of host nation assets)
Beddown Location: Fighter Distance (0mi to 3000mi distance to enemy target)		Availability of Asset (100% to 0% average mission capable rate of aircraft)
Beddown Location: Fighter Distance (0mi to 3000mi distance to enemy target)		Beddown Location: Bomber Distance (0mi to 6500mi distance to enemy target)
Beddown Location: Fighter Distance (0mi to 3000mi distance to enemy target)		Ability to Resupply (1 to 0 ratio of consumption to resupply)
Petroleum, Oil, Lubricants (100% to 0% asset sets supported per day)		Munitions Storage Area: Fighter (100% to 0% fighter sorties supported per day)
Petroleum, Oil, Lubricants (100% to 0% asset sets supported per day)		Munitions Storage Area: Bomber (100% to 0% bomber sorties supported per day)
Petroleum, Oil, Lubricants (100% to 0% asset sets supported per day)		Tanker Support Required (0 to 35 tankers required)
Topography (100% to 0% mission degradation)		Climate (100% to 0% mission degradation)
Availability of Asset (100% to 0% average mission capable rate of aircraft)		Asset Mission Flexibility (100% to 0% capability of all aerospace missions)
Availability of Asset (100% to 0% average mission capable rate of aircraft)		Asset Set Over-Utilization (0% to 100% utility of all aircraft in asset set)
Enemy Vs. USAF Capability (3 to 0 USAF to Enemy Ratio)		Enemy Surveillance, Intel, and Recon (0% to 100% operational exposure to enemy)
Enemy Vs. USAF Capability (3 to 0 USAF to Enemy Ratio)		Enemy Interference (0% to 100% mission degradation)
Topography (100% to 0% mission degradation)		Beddown Location: Fighter Distance (0mi to 3000mi distance to enemy target)

Thank you very much for your support of this research. I greatly appreciate the time you took to complete these questionnaires. I will be concluding this study with a conclusion questionnaire in which I will present the individual Campaign Specific Issue weights, as they have been determined to you. This concludes this third questionnaire.

APPENDIX H: Interview Notes

INTERVIEW NOTES: ACC SME #3 and SME #8– ACC/XOX – 1330 30 Nov

Historically, give me the platform, and I will decide what to do with it.
Need to get them to think in terms of what do you want to do?

Give example – on-going issue
Northern Watch requirements new → Look originally at F-15E's; only have so many, not really available to go any where else.

So are there other weapons system? Yes (gives examples)
Can we have certain assets flying in circles over areas...country issues

(S.S.) – Lead to political issues

SME: There are both political and risk issues
A lot higher risk of enemy threat

Political issues are broad
May be forward basing issues → Allies allowing bombers to be based in country, etc.
Bombers close to other countries (such as Russia and Chechnia)
Have unintentional consequences.

(s.s) Indirect political issues?

SME: Yes

(a.j.) Are there certain considerations along inter-political issues?

SME: Yes

POM questions – if we (The Air Force) do it (Fight the battle) and continue to do it, we get bigger slice of the pie. Upcoming QDM is an issue

Classification of LD/HD (low density/high demand) assets, such as the A-10
Navy may allow A-10 use over F-18 (applicability of use)

(S.S.) So there are direct and indirect and cross-service (political considerations)?

SME: (That's a) Good way (of putting it)

(S.S.) (What about) the favoritism of planning staff

SME: (That is a) Factor, but don't know how to quantify

The Guy who writes the thing (the plan/Request for forces) for the CINC, that's the guy with the power.

This is what I want, If don't have the component in planning, it doesn't get there

You want it on paper...what is on paper goes

Want to work like hell to get right stuff on paper

Well, I need a battlegroup, but do I need subs? No, Frigats? No. It (the battlegroup) could be tailored and can still keep others flowing on to different areas

(S.S.) Basing Considerations...

SME: Tanker support is an issue. IT was a big issue in Kosovo. We didn't have enough Limits how far we can go

Will they have to commute to the war? We opt for one asset over another because it can go farther.

Who's the opposing force? Gives threat characteristics

Anticipated AOR and beddown characteristics

Political considerations where we can operate

Kingdom (Saudi Arabia) not wanting offensive operations from their area

Most of Kuwait already at the MOG (Maximum aircraft on-ground), so we have to go to other areas

Infrastructure...how we handle the aircraft

Air refueling, Munitions. CALCMS (conventional air-launched cruise missiles)

SME: Risk is a political considerations, it's dynamic. Changes as the campaign moves on
Planners don't often know the capabilities of (our) assets

Lack of knowledge, lack of confidence is big (blue and purple suitors)

We default to the asset or weapon that we know works

Planners want what they know until they see the success of another, such as the JDAM, then we push to that

Until that happens (knowledge and confidence) occurs, it won't happen

MAJOR JOHNSON'S NOTES (at same interview):

DCAPES -

Ops to log link - Level 4 detail plans

AF component, Follow-on to COMPES

JOPES - gives level 3 detail now

Part of COMPES (deliberate and crisis action planning)

CON PLAN "Lower scale" O-plan?

Issue - Blue suit planners on unified command staffs now ask for capabilities (i.e. 15 squadron) vs. effects...i.e. want a power grid taken off-line for x hours

Chris' Question "Factors"

- Political sensitivity – (direct) forward basing (what on ally may permit)
- Risk – Loss of asset – external (indirect) perceived threat (Russia may worry)
 - Loss of life/collateral damage
- (Internal) cross-service rivalry (POM issues-funding)
- Mil issues (Tanker support?)
 - Range, payload
- Enemy sophistication (F-16 radar sufficient?)
- Beddown considerations (infrastructure)
- Lack of knowledge/confidence – mission planners selecting inappropriate asset
 - munitions become the "flavor of the month"

F-15E AGM-130 – typically only 8 aircrews/sqdrn – not trained
-- precision stand off weapon

Split ops issue – spare parts are critical!

- 4 Squadrons at Shaw
 - Two independent, 1 maybe independent, 1 not independent
 - Hence can only deploy 2 separately
- Split ops is very expensive

End of formal interview.

INTERVIEW NOTES: ACC SME#9 – ACC/XOX – 1430, 30 Nov 99

(Interview introductions, background, and reason for visit)

It sounds like you want to talk to the JOINT DEPLOYMENT PLANNING OFFICE, C2TIG, at Hurburt Field...they belong to the C2 Center AC2SR center..A3/A4, look at the AOC

Use example of Allied Force Noble Anvil

F-16 C/Js are optimized for SEAD

Efficiencies gained when combined with other missions...HARM pods

Of course, there are limits on PODS, kits, training kits, testing kits, skilled maintenance technicians, munitions troops who are smart on the HARM

Re-address how we have major weapons systems laid down

Open up FOLs, pick up and move, what's to stop us from doing so?

Do we have weapons? Inter-theater movement

Increases tanker requirements

Test equipment may or may not be there, we're limited on equipment

We need to know when they are operational

What about the airlift needed?

Barebase operations – what is the minimum time we can begin to execute (plan) and when are we ready to operate?

What needs to come in? Setup Prime BEEF, base operations, etc.

We need a communications backbone

POL, munitions

Look at combat planning, what would opening Turkey up do (for us)?

It gives us access to the area. We want to shape the battlespace!

Aerospace superiority is important, but getting there first is more (important)

Put C2ISR in (to the battlespace) at less risk, get a better picture

Combine this with overhead and ground (C2ISR), and we have a better picture (of what's going on)

We also want to mask our ability for the enemy to see what we're doing.

We want to look at the threat, our enemy's capabilities

We want to protect against our enemy finding out what we're doing

Of course, there are ways to protect against it...but then there's the "CNN" effect

Sometimes we want to let the enemy know that something is coming

We bring in C2ISR to make public what the enemy is doing (bad things)

Where we put our assets may have diplomatic impacts, and sends message (to enemy), gives us a deterrent effect

We bring in assets for deterrence or for execution

The timing of where and when to bring it in is also important

(S.S.) Would you agree that politics may affect what we bring in?

SME: Agree that political situations may affect (what we bring in)
Strict ROEs have impact... Stand-off munitions and precision guidance munitions
The CINC brings in rules, we have to go with them
Certain aircraft and configurations may be driven
We want to go to effects based planning, as we move to AEF construct
On-Call AEW – 12/12/12/6
We know the capabilities it brings, plus x number of LD/HD assets
If we plan for ahead of time what you can get, it simplifies planning
We then start to base it on effects based planning

(S.S.) Munitions?

SME:... pre-positioned both sea and land
Moving munitions by air is not efficient or cost-effective
We may bring them in at first this way, but sustainment isn't good.

(S.S.) Political Constraints?

Most political constraints deal with the sensitivities in particular country. What they're willing to accept,
Offensive capabilities? Maybe not.
Defensive capabilities? Maybe. ISR? Maybe
Of course, we can work around that, that's the purpose of the secstate (secretary of state)
It may have timing impacts, with negotiations
The planning must allow for negotiations
For a given COA, here's my optimum set, once agreed upon it may not be optimal

Site surveys, they may not be up to date. As well as base support plans. We're now looking at expeditionary support plans

The C2 center is responsible for EFX, they would be good people to talk to.

Getting folks over there – airspace restrictions enroute. Depends on the situation, the time..affects our log flow

Setting up FOLs; clearances to and from the FOL and Battlespace procedures
Combat airspace control is very important! We need to know what is going on in three dimensions...not just 1. What's coming in, what's going out. Commercial non-players

(SME: Questions interviewer)

So what will this run off of? What does it come from? What's your bandwidth? You want a tie in with existing data stores... Global Command and Control Structure.
Focus on Just In Time or Agile Logistics. Can we do it? This is a major paradigm shift!
For both logistics flow and combat planning

MAJOR JOHNSON'S NOTES (at same interview):

C2TIG group at Hurlburt field...checkout!

Make sure the A3/A4 link is there without solely focusing on J3/J4

AF may not always be the JFACC!

“Factors”

F-16 CJ is optimized for SEAD – need the HARM pod to make the system work

Split ops, bare base ops issues (infrastructure)

MOG

Tactics issues (battlespace shaping)

Multiple beddown sites add axes of attack

Information warfare/security and OPSEC – can also do in reverse...scare em with the CNN effect

Some locations/assets selections more susceptible to info flier to enemy

Surveillance assets (AWACS, RJ) placement “we’re watching you

Want to transform CINCs from asking for specific assets to specifying requirements (desired effects)

End Of Interview

INTERVIEW NOTES: ACC SME #10 – ACC/XOX – 30 Nov 99

Joint Publications is a good start.

Intangibles make campaign planning an art not so much as a science...may never be

Revolves around individual culture and purgatives of host nation

Beddown of aircraft in Turkey (Kosovo) totally driven by Turkish politics

- Where wanted to send signals to own people, other countries

- Always going to be a coalition

- We (The United States) bring \$ into the infrastructure

- Coalition politics vs. Host Nation desires

- Important of These will vary as far as nation

- Want to look at In-Theater CINC

Allied Impact

CINC's campaign planning

Impact to Enemy – actions of enemy

Will bring different things if different

Enemy Intentions/ Enemy Actions

- Often plan for most dangerous and/or most likely enemy action when transfer Oplan to Opord, want to make sure we know what the enemy is doing.

- Not only what enemy is doing, but CINC's comfort zone of risk of enemy actions

- Mission accomplishment vs. force survival – Tactical vs. Strategic

- Leads CINC's to ask for more and/or different forces than if different case

- Beddown is based on Enemy Actions and political constraints

 - Will host nations allow (us there) and allow us to fly

ROEs and host nation support

- Country approval/permission/support/sensitivities

- State Department, Ambassador, handle this, all at CINC level

Goldwater-Nichols act – all forces assigned to specific CINC, JFOR document

Host Nation politics

Nations may allow defensive operations, but not offensive

Nations may allow fighters, but not bombers

Nations may allow Stealth, may not

Nations may allow only certain countries (NATO/UN) to enter their land

National interest in the location of basing assets

US Domestic politics can be summed up in force protection...commander desire to use specific asset

--AT THIS POINT, HIERARCHY WAS INTRODUCED AS INTERVIEWEE ASKED
"WHAT ELSE?" (Several times)—

Airfield....

Approach considerations

Big since Senator Brown Crash (gives example of TACAN Dept Defense Certifications.
Must be certified to allow US pilots to land, not all UN country's certifications up to par
US Turps Criteria

Survivability Considerations: Terrain/Obstructions

Host Nation Airfield: do they have approach considerations? Is host nation Day View
Clear (Visual Approach) Only?

Weight Capability – Yes, Absolutely. Kosovo example

MSA – Yes. Port On & Off – Loading capabilities, capability of transfer from port to
Base...important for flow

Again, Host nation issues are a key

Don't have a lot of pre-positioned flow of munitions

Weight bearing limits of roads

Munitions storage capability – do they meet standards?

Non-NATO bunkers may be iffy to secure munitions

Goes into survivability, where beddown aircraft

POL – Critical issue

NATO has POL infrastructure built in, not real problem

Everyone flies JP-8

Climate/Weather – Certainly. “Do different aircraft react differently to varying weather
conditions?” No.

Rating of approach, *pilot experience* is key.

FAA rules don't apply, follow Air Force, which are more stringent

Ability to Crossover – Interrelated to all attributes of hierarchy

Ramp space, Sortie Generation

ACC/XOX office, might know WMP

CENTAF A5 – Contingency Planning at SHAW AFB

A3/DOO...DSN 965-2966

MAJOR JOHNSON'S NOTES (at same interview):

Process works pretty much as the books say – Joint pub 1

Intangibles suggest that campaign planning is more an art than a science

Beddown – driven largely by host nation – their national interests

-- Turks gave NATO 3 beddown base options

-- Draws infrastructure development (money, systems into local economy, jobs)

-- Their actions suggest intentions toward their enemies/neighbors

Coalition Operations – nothing done in a vacuum anymore
Must have a way of measuring enemy intentions and actions
CINCs comfort with understanding, risk of enemy actions
-- Friendly force survival vs. mission accomplishment
Talk to “POL MIL” advisors at a Unified Command

Domestic Politics

Joint Beddown issues

Can work against us

Not trusting replacement parts offered by host nation – thus potentially loses sorties
and hurting our relationship with the host nation

Airfield issues: approved takeoff/landing approaches at host nation beddown sites

Port throughput, roadways (for delivering support and munitions)

Approved (certified) for offloading munitions

Weight bearing limits

Munitions storage availability

WMP-5 (War and Mobilization Plan) – Classified Secret

Gives sortie durations, turn times (sortie generation ratios)

Used mostly for planning, funding purposes

END OF INTERVIEW

INTERVIEW NOTES: ACC SME #6 and SME #7 – ACC/XOX – 1 Dec 99

ACC Reacts to whims of CINCs

Mission Capable rates of the aircraft

What is best unit to select, suitable subs if non are good

HARMs target system, Pods, Test equipment availability

By time received order, force mix already determine; just choice of selecting people/places to fill

One controversy over fuse for B-2 JDAM

Current version sufficient, preferred to use new uncertified version

By the time we receive execute order, already a done deal

Lot of concern over munitions...JDAM, CALCM. Seems didn't put much forethought into mixes, allocations

Need to think what do CINCs need, not just pick and go

If you want CALCM, here's what we have, here's how many we have allocated to other places

Started off with CALCMs early, stopped later on

Think Later on, instead of using all first off; use more smartly

HGS Pods systems (HARM) – emptied out Shaw to keep Kosovo going

(SME #6 inserts...)

Alert forces – 2nd plan to send more people in

Size of Augmentation force depended upon COA

CINC now asks for LD/HD first – want to see everything at all times

(Maj S.S.) Do any factor's change?

(SME#7) Beddown, Target Sets – NATO determined TSs, delayed ATO generation

(SME#6) Turkey only allowed Mil-Air in

LBM – Load Bearing Capability of runway...became an issue

Looking at both what and where to beddown

Turkey has strict rules; tried to bring beddown equipment in on 747's

High LBM (78-80 psi) – Turkish runways couldn't handle it

(SME #6) Sometimes they make you do that – “you can land here, but you'll pay for it”

Looked like Turkey held off initially (on letting us beddown)

Most forces (for Kosovo) were in Italy and England, no big culture issues

Trucking and rail can be an issue

Can't always “FedEX” – Limits on what can bring in commercially

(Maj S.S.) Any issues like national government's required who does stuff? (i.e. G.I.s)

We try to minimize footprint, encourages host nations to provide support

USAFE could talk Host Nation (better than us)

MSgt Caldwell – Contracting NCO, worked Ramstein Issues (ext 5096)

If system can tap into current information, people can see what's available and tailor from there –instead of sending entire UTC, bring an aircraft
(We're) in the process of breaking down UTCs from 18-24 ship to 6 ship
Agile Combat Support – Setting up EAF center for 1 stop shop POC for info
ID types/quantities of equipment needed
Want to have recommended cargo deployment listings
Unless you have the entire support operation at the Forward Operating Location (FOL),
Can't do split-ops... Talk to ACC/XOD
Spares, Test-equipment, and troops are an issue
Cross-training of pilots in multi-role (missions) is an issue

MAJOR JOHNSON'S NOTES (at same interview):

Log planner – experience in Kosovo battle planning staff
Force mix already identified – his job partly to find the best units to fill

Mission capable Rates – what units best to send (for given capability)

Concern on munitions

Operators wanted a particular JDAM fuse – hadn't passed OT&E though
Not much forethought on munitions planning
CALCM example (they were probably overused initially)

LD/HD issues – everyone wants them

PAX mostly restricted to mil air

Restrictions on commercial shippers – Turkey only allows DHL

(SME #6)

Agile Combat Support –stand up an AEF center – so deploying units have a single point to call for logistics issues (AGE, etc)
Improve comm, asset visibility
Deploying units then won't have to take an entire UTC

Split Ops – 6 of 24 deploying F-15s would need 75% (*given estimate, not hard fact*) of the squadron's support – won't work!
Split ops briefing (ACC/XO) shows costs for people, support equip in a Northern Watch issues

END OF INTERVIEW

INTERVIEW NOTES: ACC SME #5 – ACC/XOX – 0855 1 Dec 99

Interview Introduction and summary by Lt Buzo

Biggest (issue) is human – “I want” vs. practical

ACC sources/tasks/flows

Look at LIMFACS (Limiting Factors)

We need a leader (in a crisis) who is willing to make decisions

We get into decision loops – leads to delays, indecisiveness

A good plan today is better than a perfect plan next week – Gen Patton

Need to be careful that we don't fall into this trap of waiting forever

In perspective – Deployment orders

UCOMM – planning incrementalized air war – USAFE Lead

Began to develop plans; what are weapons we need, then look at weapons systems to deploy these weapons

Human interjection comes in “I want this aircraft” (Human Factor)

Really, what is capability...capability vs. weapons systems, we don't have unlimited assets

Global Military Force Policy

Tends toward AF – HD/LD assets, monitors use

F-117, B-2, not under GMFP, but don't have that many

Look in terms of capability vs. Desired effect

2 Problems...

Lock ourselves into plan we can't live up to

Competing priorities of aircraft

Availability of weapons is another important issue...CALCMS

USAFE makes Christmas list of needs

1st source in-theater, shows short-falls, send up to UCOM for validation

Sanity check, UCOM sends Request For Forces up to JCS

GMFP – Steady state (everyday), Surge (costs in air frame, personnel, up to 60 days in length, then reconstitute), No-Kidding all out war (Everything out, not very long if at all)

For some aircraft (U-2) pilots are strong LIMFAC, becoming worse

JS does scrub on GMFP – says you can have X

Goes to JFCOM, source at ACC

ACC goes...you can have X, need to wait on Y

Invites problems on human side

Would be better to request capabilities

ACC sends back comments – JC comes back with deployment order

With technology (e-mail) almost a bartering system

Produces proliferation of orders – get new before can adequately CHOP previous

Need to see to Joint community a change in doctrine

Joint Forces Command J33

Advocates for Joint World

TRANSCOM

Who controls Assets/PACOM/EUCOM/CENTCOM in and out of AOR is important

OPCON should transfer in and out of AOR

Bombers – Jstaff thinks you may have so many in reserve, really don't (B-2 ex)

Want 2, think have 18 in reserve, but don't

GEO Political issues

Italy doesn't like B-52s...keep in air, requires more tanker support than if could have in Italy

Offensive vs. Defensive capability

B-2s – basing is an extreme problem

Money does drive decision, can't advocate it

Doesn't care about the dollar, but generals do

INTER/INTRA political issues

B-2 pushed into Kosovo, F-117 same

Human factor – humans have to make decision

Need to convince leaders to be leaders and make decisions

Talk to WHITMAN folks who handled Kosovo war in Conus

Issues they have on factors "from home"

MAJOR JOHNSON'S NOTES (at same interview):

Human issues (what I want, vs. what I need)

Concerned that more choice will exaggerate indecisiveness

Decision loops get too long (good early decisions usually better than the best late decision)

"I need F-117s because they're cool" – we think of what we want, vs. what we need

Need to express needs in terms of desired effects

Capability vs. MDS (requirement for)

Global Military Force Policy (GMFP)

SECDEF program that monitors LD/HD assets

Email speed causes too much "what ifting"

Lose track of what the real deployment order is, for example

Geopolitical issues

Italy, Spain don't mind fighters, but hate B-52's (nuke stink)

Kosovo...good to loiter B-52s with CALCMs...if fly from Fairford, will need air refueling, but if could fly from Italy, would not need air refuel)

Cost – “military should not worry about costs...but the generals do”

B-2's would be costly to deploy (basing)...”a fussy aircraft”

B-2's are being used, partially to justify its existence

Suggests we talk to Whiteman AFB on their CONUS support of Kosovo (B-2's)

Either wing cc or ops commander

What worked or didn't work

Do it fast, before expertise melts away

END OF INTERVIEW

INTERVIEW NOTES: ACC/SME#11 – USAFE – 1 Dec 1210

Inter-service political pressure

Army is usually the JTF

Requirements for collateral damage, casualty minimization (0)

Achieving (trying to) psychological effect

Knowledge of airpower, systems

Political considerations affect target sets from get-go

Feedback of what we have vs. what we want to target

National support/improvement of infrastructure we bring

Logistics tail – C-5 break rates, can't always depend on when things/supplies coming in

Survey analysis/site surveys need to be consolidated and improved

MAJOR JOHNSON'S NOTES (at same interview):

Doctrine – what service calls the shots?

Pace – “gradualism” used in Kosovo

How fast/scale is the target list addressed?

Capabilities affect target chosen

As bad as JOPES is, its light years ahead of other nations

Beddown data collection needs to be improved

AMC collects only what they're interested in

Lots of surveys done now, but data integration/dissemination must be done better

END OF INTERVIEW

INTERVIEW NOTES: HQ/USAF SME #2 – AF/XOPX – 7 Dec 99

EAF concept – lead to requirements-based force

“what do you want... we'll give it to you”

Fighter community forward operations – not conformed to hand purpose of EAF

Doesn't really affect LD/HD – doesn't change their schedules

Overflight is political @ a high level – not really constrained to specific aircraft

Could be country wanting specific aircraft

Pilots limit capability

ISR – UAV's Army information obtained may not get to AF

Historically, look at CINCs – look at how reqt's changed as color of suit changes... who the CINC is

B-2/Stealth aircraft in Kosovo – going to use it

Life Span/Cost – Risk/Reliability of aircraft

A-10 extended – wanted to transfer to Army – Army's Air Force weapon of choice

END OF INTERVIEW

INTERVIEW NOTES: HQ/USAF SME #3 – AF/XOOC – 8 DEC 99

Maintainability of Aircraft

Fuel and Munitions – be there or not...don't have instantly

Basing considerations...Beddown location. Distance to Target

Affects refueling considerations

Enemy Capabilities

Enemy Air Defense Simulator is a good tool

Risk!

Force closure – real time Ops and logistics

Introduced into interview: HQ/USAF SME # 6 and SME # 7

Type of munition you have

DMPE – within target array

PK requirements – drives # of airframes to weaponeering

RISK! – stealth of standoff if risk is high enough

Other mission requirement; may require CAS or SEAD, etc.

Used everything else...OPS TEMPO of specific assets

Weather drives where locations are located (overall weather, not day-to-day)

Commander's desire

Speak with CENTAF – 9th AF.

Look at the Capabilities Based Logistics Plan and Operations Planner

Software decision support tools that succeed JPT

If you can start with a set of MRRs, only bring what you need

Air staff is developing 3,6,and 9 ship UTCs → build-up from there if needed.

END OF INTERVIEW

INTERVIEW NOTES: HQ/USAF SME #8 and SME #9 – AF/XOPW – 8 Dec 99

Theater CINC delineates capabilities and PGM, OCA/DCA

Still sometimes ask for specific equipment

Look at AEFs in UTC construct, pick out ULNs into TPFDD

Identify specific forces

(SME #9) TPFDD libraries – 10 AEF, 2 AEWs, and 1 “Enabler”

go into these buckets, depending upon locations, and look for capabilities in buckets...peel out what's needed

Contingency portion of AEF forces are used in steady state – look in units to see if you have enough forces

(look at SORTS/Persons/Tasking elsewhere) If no, look to AEW

Capability full of UTCs

Go down AEF list if don't have required number of assets

On issues –

Beddown – if can't get beddown close to fight, go to different asset

Cross section – Aircraft size/stealth

Sometimes political, sometimes site survey

Availability of munitions is a factor

Tasked for MTW? Doesn't want to pull asset from another event

Status of aircraft

Some assumptions made – weather, staging locations, some of ROEs could come up

Political issues can come up front, first

All delineated in planning assumptions, often assume away issues (such as weather)

Weather should be expected

Support comes with aircraft

SVS, Weather, Comm, etc...meat of deployment

“What do you need to do?”

CINC asks for capability

Might be service politics to choose with aircraft to use

(SME #9) wouldn't use as factor

Enemy capabilities? Yes

Air defense capabilities? Stand-off

Ground protection

Possible reason why B-2 deployed from CONUS

Look at AF 10-400, AEF instruction

SITE Surveys

Ground capable of grining in aircraft? Ramp space?
Fuel/ Fuels source considerations

Beddown – CONOPs

Might not be able to discern political concerns

Commonality of maintenance

Don't want multiple beddowns of one aircraft – economies of scale
May be assumption that we get host nation support for asset
Host Nation Support Agreement

Capabilities of common aircraft among different nations

Could be a political consideration
Reserve components? Should they be activated?

END OF INTERVIEW

INTERVIEW NOTES: AU SME #3 – JDACC – 10 DEC 99

Joint Doctrine Air Campaign Course evolved from Checkmate

Desert Storm, didn't have a great way to plan

Developed from Joint Doctrine 3.56-1

2 week-course – a lot of AF, but also other 3 services go

Go through 5 stages of campaign planning

Use air-power in most effective way

Mostly operator oriented

Confirm what the air power can do

Concept Validate – confirm with Centers of Gravity

Not really Deliberate Action Planning

Focuses on Process, not Product

Realizes there are factors or “constraints” and “restraints”...drive of class is to get students to think about these

Did not have any taught or presented list of “constraints” or “restraints”

Suggested speaking to JAK2C course instructors at Hurlburt field
(DSN 487-4409) JDACC course

Possible issues

Logistics concerns and support

Enemy's in-ability to fight @ night...want to capitalize on that

Intra-service issues can arise

Staging locations – countries not letting them fly in offensive weapons

You have to talk-talk-talk your way through the planning process

Communication is Key

Could be on your own – don't depend on coalition forces, but do look to Joint Services

END OF INTERVIEW

INTERVIEW NOTES: AU SME #2 and SME#4 – CWPC

Asked if I had studied the TARGET analysis tool.

In any contingency, have deliberate planning process

Want to understand AOR...ROE, assumptions, should initially be thought about

Look @ 5 stages of development – develop plan, approve, then shelve for later use

Warfighting CINCs will make requests to supporting staff

Need to ask “what effect do I want to achieve?”

Example of Kosovo – ran out of CALCMs – more dependent on technology

Better deliberate planning leads to a better operation

HD/LD assets

Security issues (high value)...reasons why we fly B-2s from Whiteman

Political issues

We have problems communicating our capabilities and doctrine

Way we operated spread out, compared to other services, did not effectively show true capabilities.

We had this, and this, and that, but couldn't effectively show

AEF/AEW in effect will help better present our capabilities

We need complete force visibility for the concept to work

Guard and Reserves! Almost all AEF/AEW deployments will require

Guard/Reserve call-up

Could be a trust issue – Do CINCs have confidence in the platform?

CINC must have trust and education of capabilities of platforms

Requires complete Operations Environment Research! (Stage I of planning)

Described through the flow of request/information from JFC to ACC

What's already in theater (pre-positioned assets)

Host Nation Support – what will they/what can they support

Lift requirements

Coalitions forces

Operations vs. Logistics – spread out assets vs. combined.

Benefits and drawbacks to each

Bottom line is “personalities” run things

People go on experience

Education is key

Make planners aware of the tools and platforms we have available

GCCS

TARGET – COA analysis

A JOPES specialty course – held at Fort Eustis, VA
DSAG – Deployment Special Action Group (J4 @ Joint Staff)

AF-Logistics Management Agency – Gunter

DSN 596-4087/88

SAAS – Studies of Advanced Airpower

In-depth airpower studies

Affect doctrine – smart folks

AF Doctrine Center

Lack of standardization of “tools” across AF

Purpose of IDS (Integrated Deployment Systems)

Integrates MANPER/LOGMOD/DMES/COMPRESS

Deliberate and Crisis Action Planning Systems

Trust/Commander Requirement

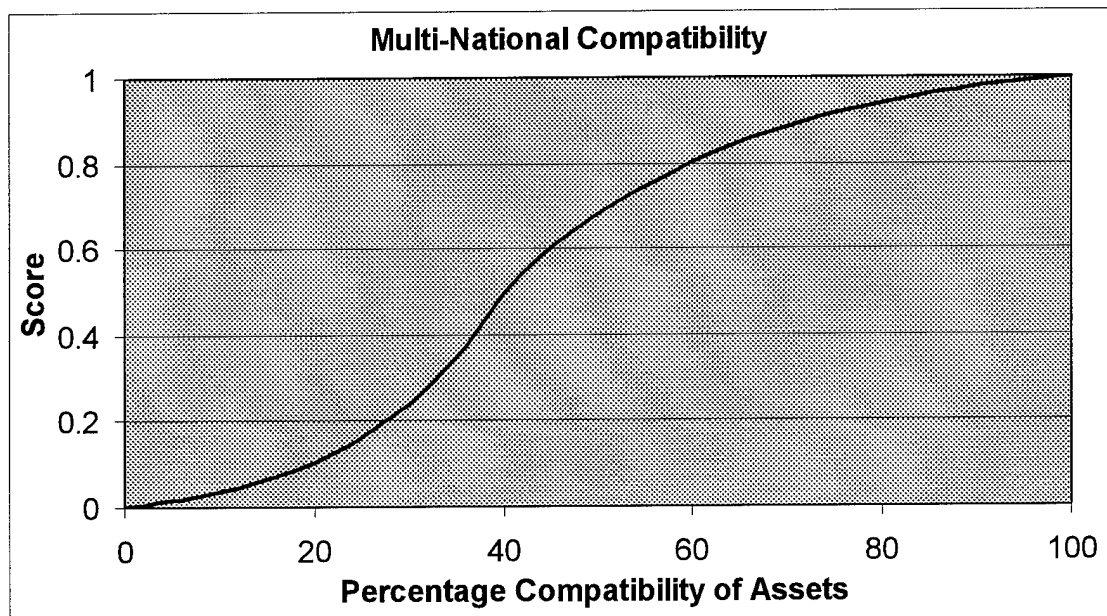
Intra-service information flow

All of this requires a significant Culture Change!!!

END OF INTERVIEW

APPENDIX I: CENTAF Confirmed Value Functions With Definitions

MULTI-NATIONAL COMPATIBILITY



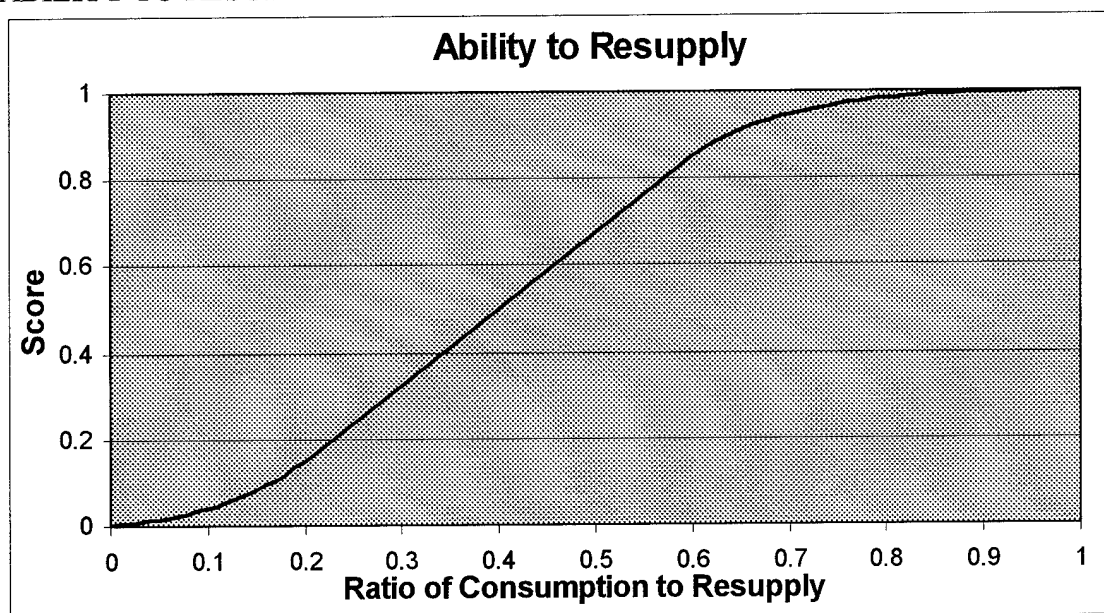
CALCULATION INFORMATION			
Percent	Score		
100	1		
40	0.5	Rho	-25
0	0	Rho	15

Description: Extent to which host-nation assets, to include combat aircraft, equipment, spares, and support equipment can be incorporated along side and into USAF combat aircraft.

Measurement: "Percentage Compatibility of Assets." 0 – 100 percent. At 100 percent compatibility, the staging base that the host nation maintains and operates like assets for 100 percent of the assets in the asset set. USAF combat aircraft can be incorporated into the staging base without bringing in testing equipment, spares, or excessive maintenance equipment. At 0 percent, all of the assets in the asset set are different (no like assets between United States Air Force combat aircraft and host nation combat aircraft). In this situation, campaign planners would need to bring a complete supply of testing equipment, spares, and maintenance and repair equipment for all combat aircraft brought into the staging base. The entire range of percentages of host-nation compatibility is possible.

Confirmed: 14 JAN 00 by CENTAF

ABILITY TO RESUPPLY



CALCULATION INFORMATION

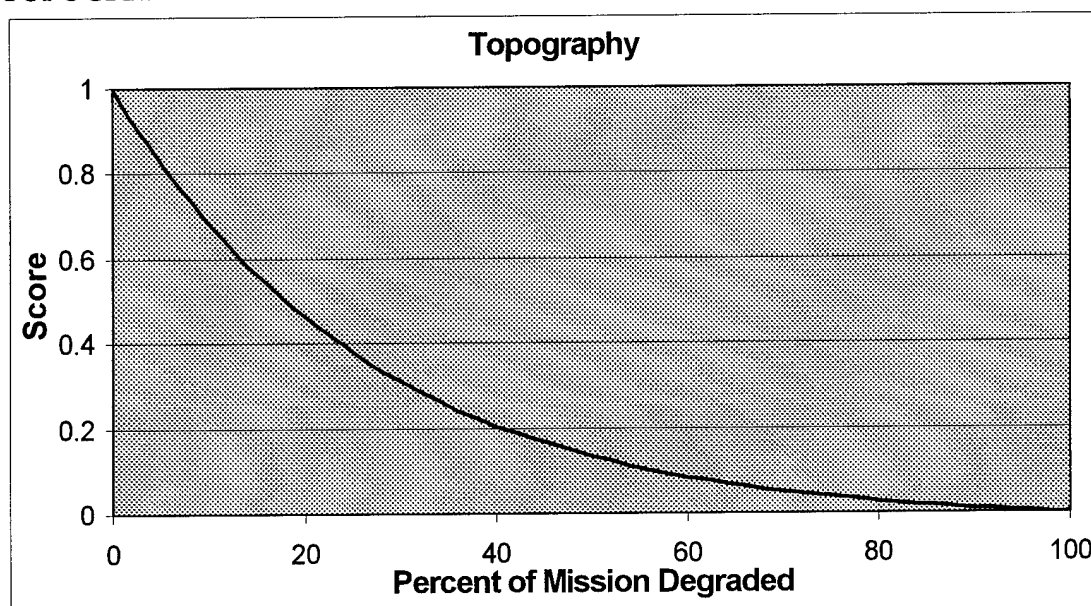
Ratio	Score		
0	0		
0.2	0.15	Rho	0.1
0.6	0.85		
1	1	Rho	-0.1

Description: Continued combat operations from the staging base are dependent upon the ability of USAF force's equipment and materials to be resupplied. Assuming the staging base has been predetermined, the selection of combat aircraft assets will be dependent upon individual asset's resupply requirements. Combat aircraft that require smaller amounts of POL, munitions, and other equipment will have a higher inherent value than an aircraft type that requires more assets.

Measurement: "Ratio of Resupply to Consumption to." 0 – 1. At the ratio of resupply to consumption increases to 1, US force's ability to resupply the staging base with required equipment and materials (i.e. munitions, aircraft replacement parts) for an aircraft asset is equal to the consumption of those same equipment and materials. As the ratio of resupply to consumption decreases to 0, combat aircraft consumption rates far exceed our force's ability to resupply the staging base. Ratios above 1 would not be experienced, as they imply assets are being shipped to the staging base location that are not needed. The entire range of ratios of resupply to consumption is possible.

Confirmed: 14 JAN 00 by CENTAF

TOPOGRAPHY



CALCULATION INFORMATION

Topography

Difficulties

Score

0

1

1

0

Rho

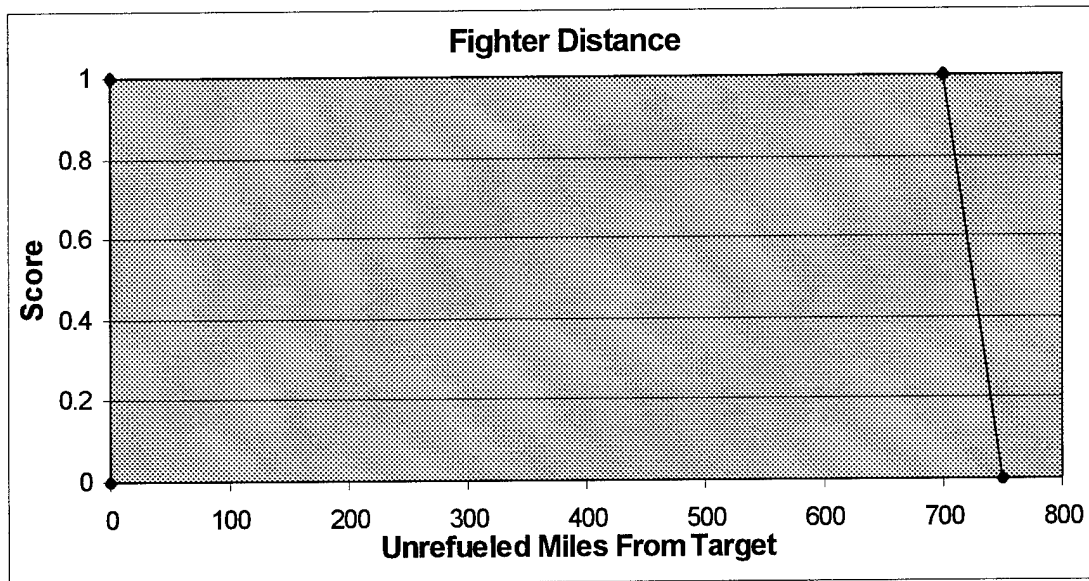
-0.27

Description: The extent to which natural and man-made land formations around the pre-determined staging base effects the ability of individual aircraft assets within an asset set to take-off and land at the staging base.

Measurement: "Degradation of Mission." 0 – 100 percent. At 100 percent mission degradation, no sorties can fly in or out of the staging base due to topographical restrictions. 100 percent mission degradation, is a theoretical maximum, because if all aircraft assets could not take-off from the staging base with enough munitions to successfully accomplish the mission, those aircraft would be directed to a different staging base. At 0 percent mission degradation, all aircraft can fly sorties out of and return to the staging base with enough munitions and fuel to successfully complete the required aerospace missions. At 50 percent mission degradation, combat aircraft can fly into and out of the staging base at 50 percent capability. 50 percent capability is defined as an aircraft asset that can only be configured with enough fuel and munitions to achieve a 50 percent probability of kill over the enemy target. The entire range of percentages of degradation of mission due to staging base location topography is possible.

Confirmed: 14 JAN 00 by CENTAF

FIGHTER DISTANCE: UNREFUELED



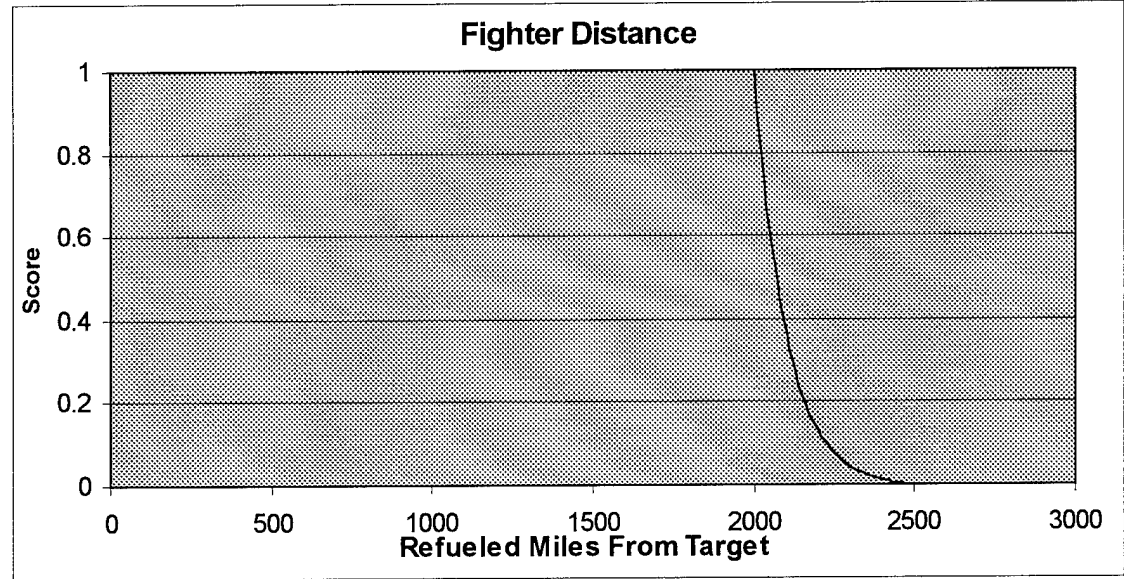
CALCULATION INFORMATION		
Unrefueled		
Miles (1000) from		
Target	Score	
0	1	
0.7	1	
0.75	0	

Description: The effectiveness of an individual asset within the asset set is dependent upon the distance from the staging base to the target.

Measurement: "Distance (miles) From Target." 0 – 6000 miles. This measure scores the location of the staging base from the general enemy target area. Bomber and fighter assets have different distance abilities; therefore, each has a separate curve. Additionally, separate curves are required for refueled and un-refueled operations. It has been determined for this analysis that 6000 miles is the effective distance of bomber assets due to crew capabilities. The effective range of a fighter aircraft, determined for this analysis, is 2500 miles, due to crew capabilities. For each type of aircraft (fighter or bomber), the entire range of effective distances within their specific ranges is possible.

Confirmed: 14 JAN 00 by CENTAF

FIGHTER DISTANCE: REFUELED



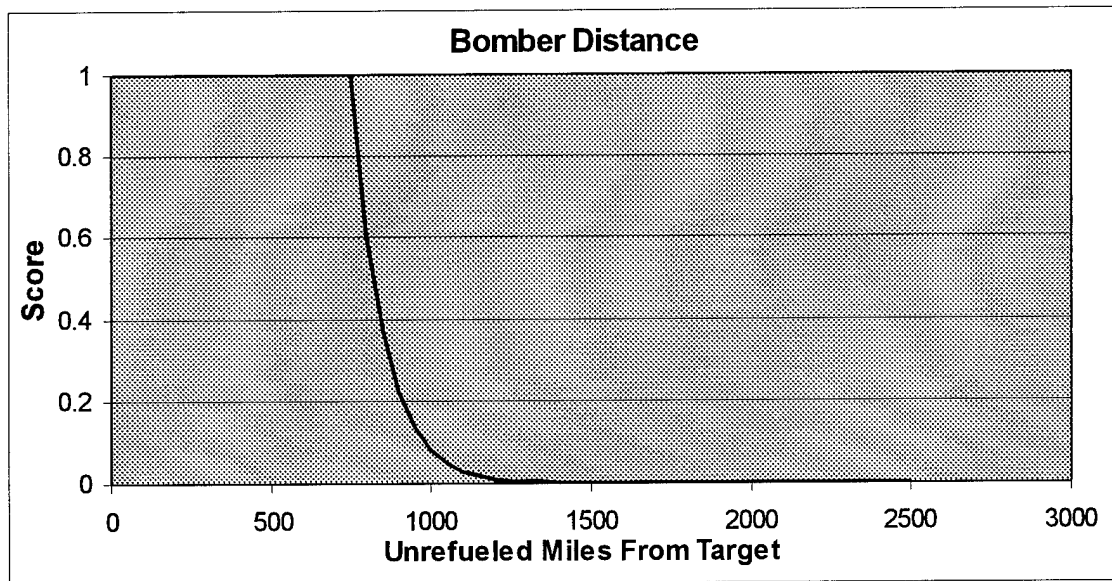
CALCULATION INFORMATION				
Refueled				
Miles (1000) from				
Target	Score			
0	1			
2	1			
2.5	0			
	Rho	-0.1		

Description: See Fighter Distance: Unrefueled

Measurement: See Fighter Distance: Unrefueled

Confirmed: 14 JAN 00 by CENTAF

BOMBER DISTANCE: UNREFUELED



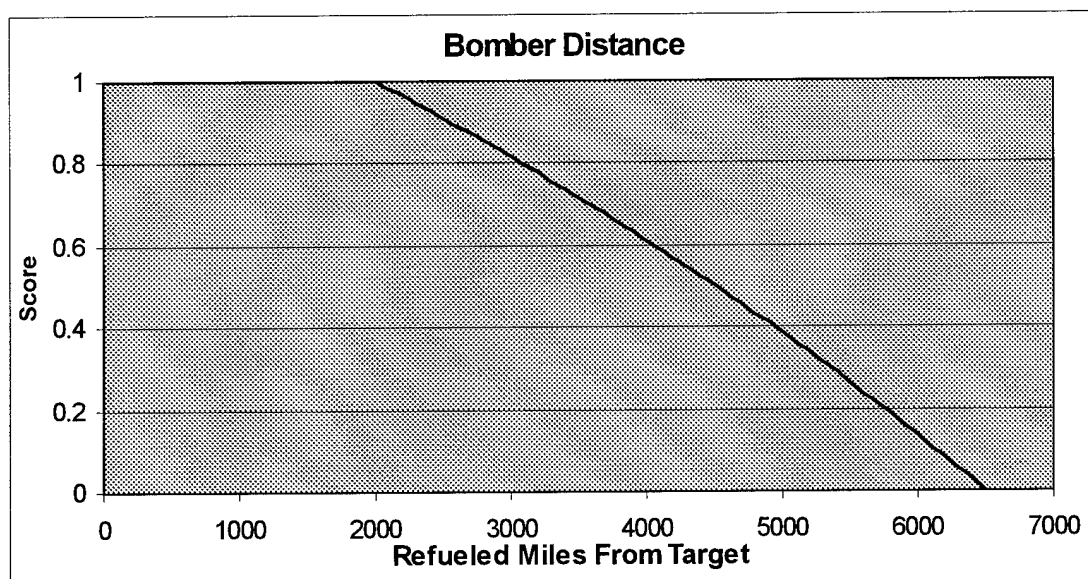
CALCULATION INFORMATION				
Unrefueled				
Miles (1000) from				
Target	Score			
0	1			
1	1			
2.5	0			
	Rho	-0.1		

Description: The effectiveness of an individual asset within the asset set is dependent upon the distance from the staging base to the target.

Measurement: "Distance (miles) From Target." 0 – 6000 miles. This measure scores the location of the staging base from the general enemy target area. Bomber and fighter assets have different distance abilities; therefore, each has a separate curve. Additionally, separate curves are required for refueled and un-refueled operations. It has been determined for this analysis that 6000 miles is the effective distance of bomber assets due to crew capabilities. The effective range of a fighter aircraft, determined for this analysis, is 2500 miles, due to crew capabilities. For each type of aircraft (fighter or bomber), the entire range of effective distances within their specific ranges is possible.

Confirmed: 14 JAN 00 by CENTAF

BOMBER DISTANCE: REFUELED



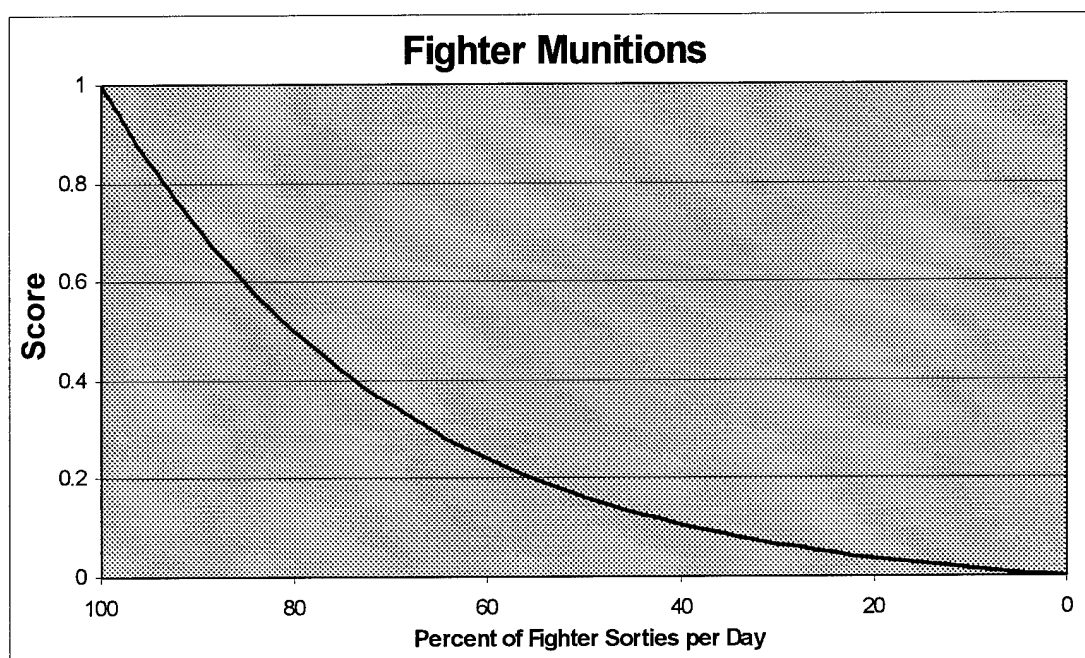
CALCULATION INFORMATION			
Refueled			
Miles (1000) from			
Target	Score		
0	1		
2	1		
6.5	0	Rho	9.959581

Description: See Bomber Distance: Unrefueled

Measurement: See Bomber Distance: Unrefueled

Confirmed: 14 JAN 00 by CENTAF

MUNITIONS STORAGE AREA: FIGHTER MUNITIONS



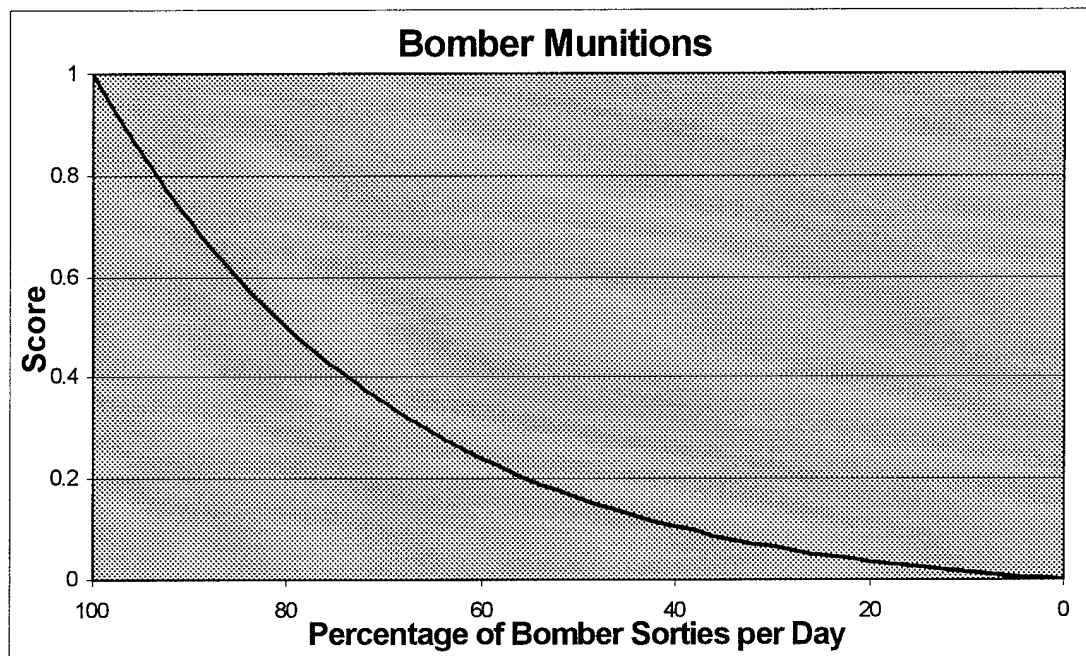
CALCULATION INFORMATION			
%			
Sorties/Day	Score		
0	0		
1	1	Rho	-0.305

Description: Continued fighter operations depend heavily on the pre-determined staging base's ability to store specific munitions for fighter operations. Fighter aircraft can only bring one load of munitions; additional sorties require the ability of the staging base to re-load the fighter.

Measurement: "Fighter Sorties per Day." 0 – 100 percent. At 100 percent sortie rate per day, the staging base's munitions storage area (MSA), (includes storage and supply) can support 100 percent of the Commander in Chief's (CINCs) fighter sortie requirements per day. At 0 percent sortie rate per day, no sorties can be supported. While 0 percent is theoretically possible, 0 percent is not likely, because if the staging base could not store the required munitions for a particular fighter sortie, another aircraft alternative would be selected. At 50 percent sortie rate per day, only 50 percent of the sorties required of the particular aircraft asset can be conducted. The entire range of percentages of fighter sorties per day supported is possible.

Confirmed: 14 JAN 00 by CENTAF

MUNITIONS STORAGE AREA: BOMBER MUNITIONS



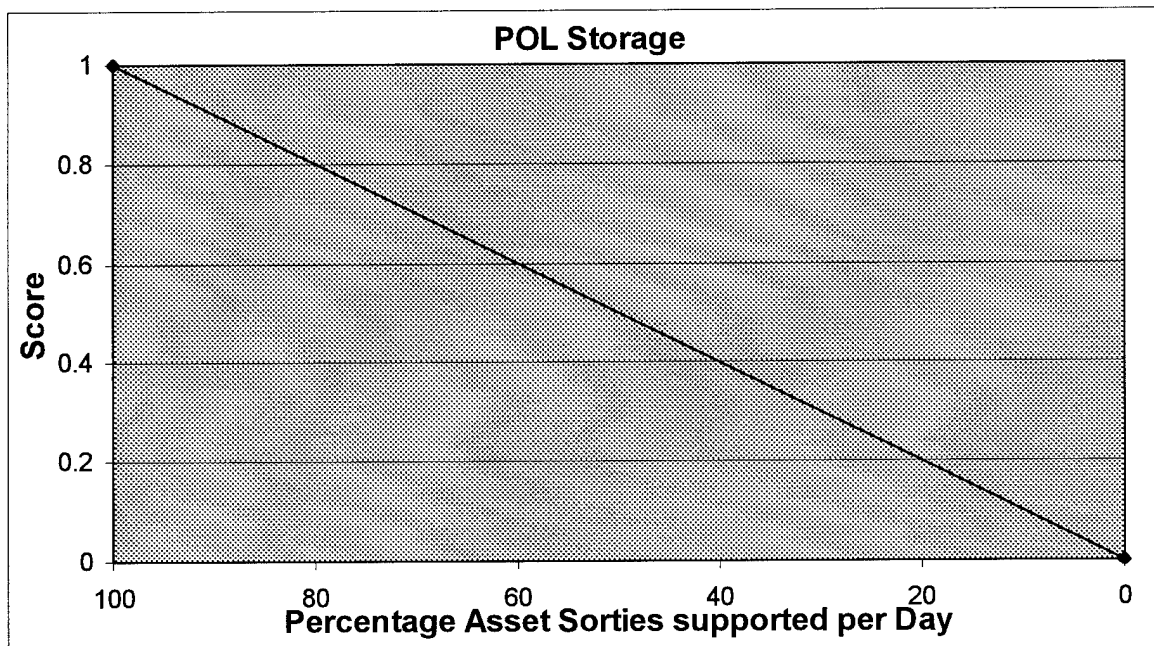
CALCULATION INFORMATION			
%			
Sorties/Day	Score		
0	0		
1	1	Rho	-0.305

Description: Continued bomber operations depend on the pre-determined staging base's ability to store specific munitions for bomber operations. Bomber aircraft can only bring one load of munitions; additional sorties require the ability of the staging base to re-load the fighter.

Measurement: "Bomber Sorties per Day." 0 – 100 percent. At 100 percent sortie rate per day, the staging base's munitions storage area (MSA), (includes storage and supply) can support 100 percent of the Commander in Chief's (CINCs) bomber sortie requirements per day. At 0 percent sortie rate per day, no sorties can be supported. While 0 percent is theoretically possible, 0 percent is not likely, because if the staging base could not store the required munitions for a particular bomber sortie, the bomber aircraft would re-locate to another staging base or another aircraft alternative would be used. At 50 percent sortie rate per day, only 50 percent of the sorties required of the particular aircraft asset can be conducted. The entire range of percentages of bomber sorties per day supported is possible.

Confirmed: 14 JAN 00 by CENTAF

POL STORAGE



CALCULATION INFORMATION

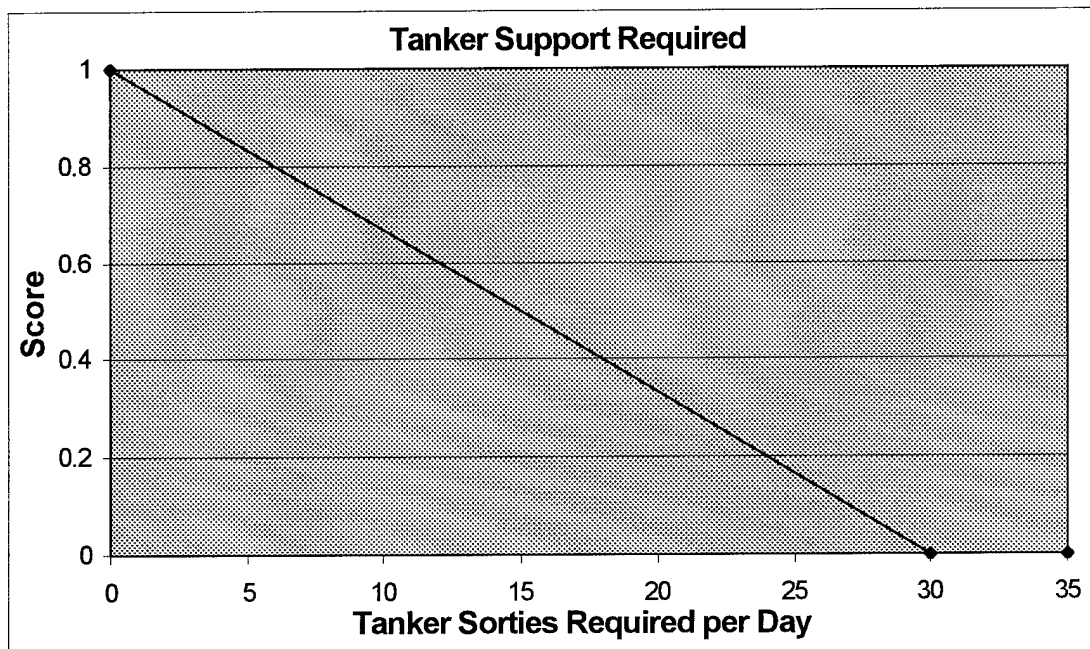
Sortie	
Missions/Day	Score
0	0
1	1

Description: The staging base's POL system includes storage and supply from both military and host-nation contracted sources. POL capability for a particular asset set must take into consideration the per-sortie POL requirements of each individual aircraft in the asset set as well as the daily sortie requirements for each individual aircraft.

Measurement: "Mission Capability." 0 – 100 percent. At 100 percent mission capability, the staging base POL system can support 100 percent of the Commander in Chief's (CINC's) sortie requirements, whether the POL comes from on-base or off-base contracted sources. At 0 percent mission capability, no sorties can be supported. While 0 percent is theoretically possible, if 0 percent capability were experienced, aircraft assets would be directed to a different staging base. The entire range of percentages of mission capability due to POL storage and supply is possible.

Confirmed: 14 JAN 00 by CENTAF

TANKER SUPPORT REQUIRED



CALCULATION INFORMATION

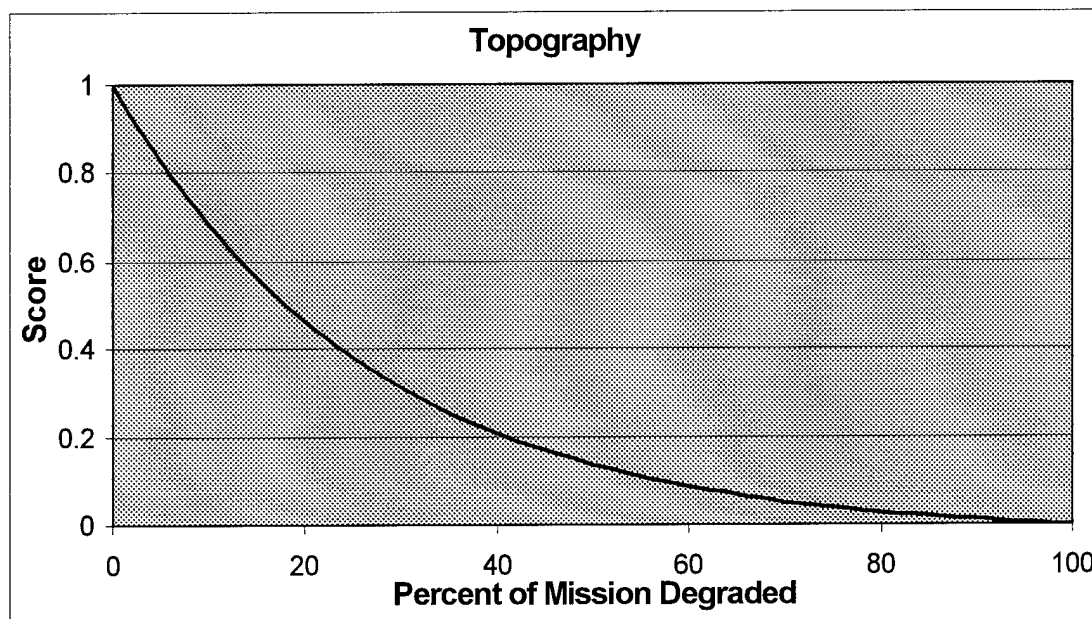
Tanker Sortie	
Missions/Day Score	
0	1
30	0
35	0

Description: Depending upon the location of the staging base from the enemy target and the fuel requirements per aircraft asset sortie, and the number of aircraft assets conducting sorties at a particular time, multiple tanker assets may be required.

Measurement: "Tankers Required." 0 – 10. This measure scores the number of tankers required in the theater to support asset set sorties. Depending upon the fuel requirements for a particular aircraft asset and the distance between the staging base and enemy target, tanker assets may be required. Additionally, the intensity of combat in and around the enemy target may require tanker support. Note, this measure only counts tanker that are specifically dedicated to combat operations; cargo and intelligence gathering aircraft are not considered. This measure counts actual numbers of tankers required over the area of responsibility, and not tanker sorties. No tankers required (0) would be experienced if combat operations did not require aerial refueling. Ten tankers required (10) would be experienced if combat operations required an extensive amount of sustained aerial operations. The entire range of number of tankers required is possible, although 10 tankers required are a theoretical maximum.

Confirmed: 14 JAN 00 by CENTAF

TOPOGRAPHY



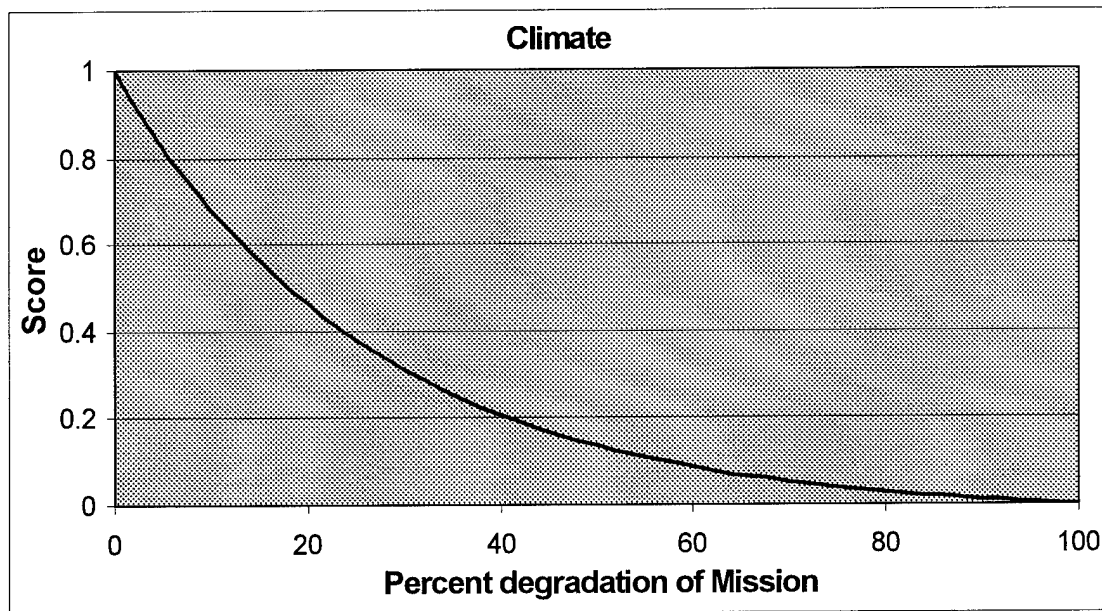
CALCULATION INFORMATION			
Topography			
Difficulties	Score		
0	1		
1	0	Rho	-0.27

Description: The extent to which natural and man-made land formations around the pre-determined staging base effects the ability of individual aircraft assets within an asset set to take-off and land at the staging base.

Measurement: "Degradation of Mission." 0 – 100 percent. At 100 percent mission degradation, no sorties can fly in or out of the staging base due to topographical restrictions. 100 percent mission degradation, is a theoretical maximum, because if all aircraft assets could not take-off from the staging base with enough munitions to successfully accomplish the mission, those aircraft would be directed to a different staging base. At 0 percent mission degradation, all aircraft can fly sorties out of and return to the staging base with enough munitions and fuel to successfully complete the required aerospace missions. At 50 percent mission degradation, combat aircraft can fly into and out of the staging base at 50 percent capability. 50 percent capability is defined as an aircraft asset that can only be configured with enough fuel and munitions to achieve a 50 percent probability of kill over the enemy target. The entire range of percentages of degradation of mission due to staging base location topography is possible.

Confirmed: 14 JAN 00 by CENTAF

CLIMATE



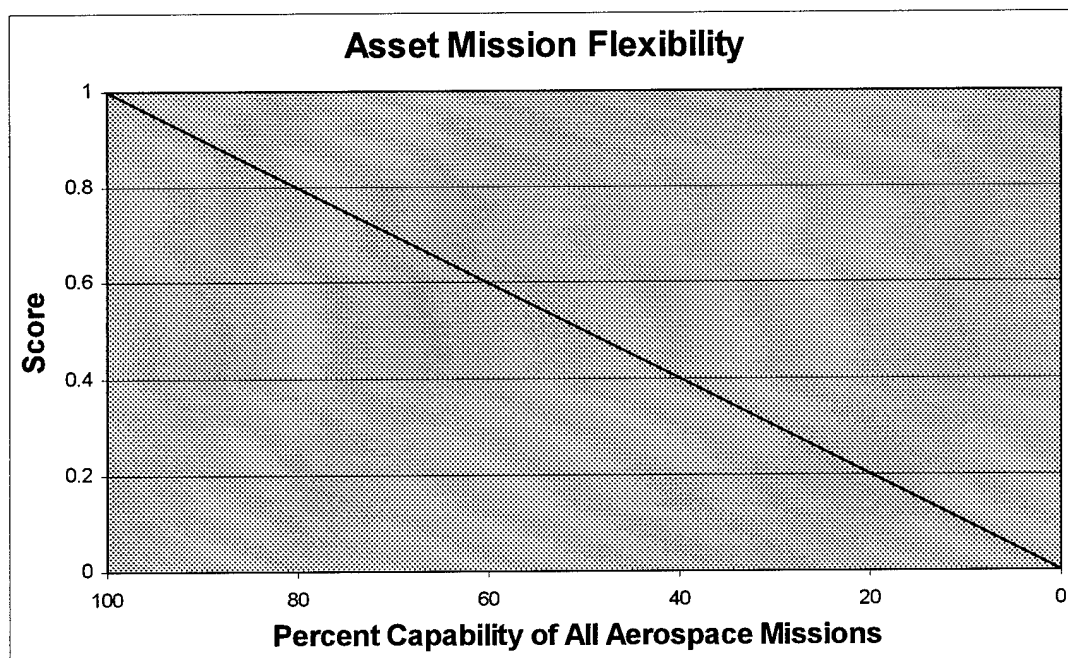
CALCULATION INFORMATION				
Climate				
Affect	Score			
	0	1		
	1	0	Rho	-0.27

Description: The extent to which heat, humidity, adverse wind and atmospheric pressure would affect the ability of particular aircraft assets to conduct combat operations.

Measurement: "Degradation of Mission." 0 – 100 percent. At 100 percent Mission Degradation, no sorties can fly. This is a theoretical maximum degradation of mission, because if, for instance, the cross winds at the staging base were such that a particular aircraft asset could not land, that aircraft asset would be directed to another base. At 0 percent Mission Degradation, all sorties (all aircraft) can fly at 100 percent capability. At 50 percent Mission Degradation, An aircraft asset can only take-off at 50 percent all sorties (all aircraft) can fly at 50 percent capability (i.e. only 50 percent of maximum munitions loading for bombers). The entire range of percentages of mission degradation due to climate is possible.

Confirmed: 14 JAN 00 by CENTAF

ASSET MISSION FLEXIBILITY



CALCULATION INFORMATION

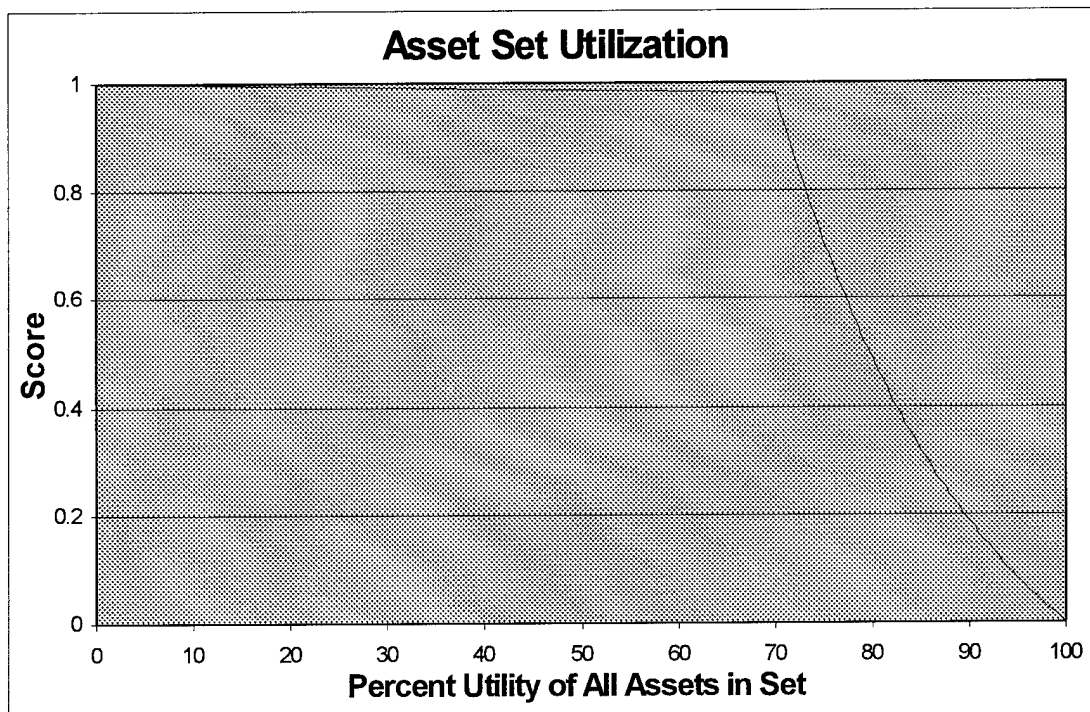
Percent Mission Capable	Score
0	0
1	1

Description: Extent to which the aircraft within the asset set can perform all of the possible aerospace missions defined in AFM 1-1 and AFDD 2-1. The relative worth of the asset set would be high if that asset set could perform any mission required by the theater commander.

Measurement: "Percent Capability of All Aerospace Missions." 0 – 100 percent. At 0 percent aerospace mission capability, the assets in the asset set cannot perform any aerospace combat mission required by the theater Commander in Chief (CINC). This is a theoretical minimum, as all aircraft assets are capable of performing at least one aerospace mission. At 100 percent aerospace mission capability, the assets in the asset set can perform any and all of the aerospace combat missions that could possibly be required by the theater CINC. 100 percent aerospace mission capability is achieved if the assets in the asset set can collectively perform all of the aerospace combat missions as defined in Air Force Manual 1-1 and Air Force Doctrine Document 2-1. The entire range of percentages of aerospace mission capability is possible.

Confirmed: 14 JAN 00 by CENTAF

ASSET SET UTILIZATION



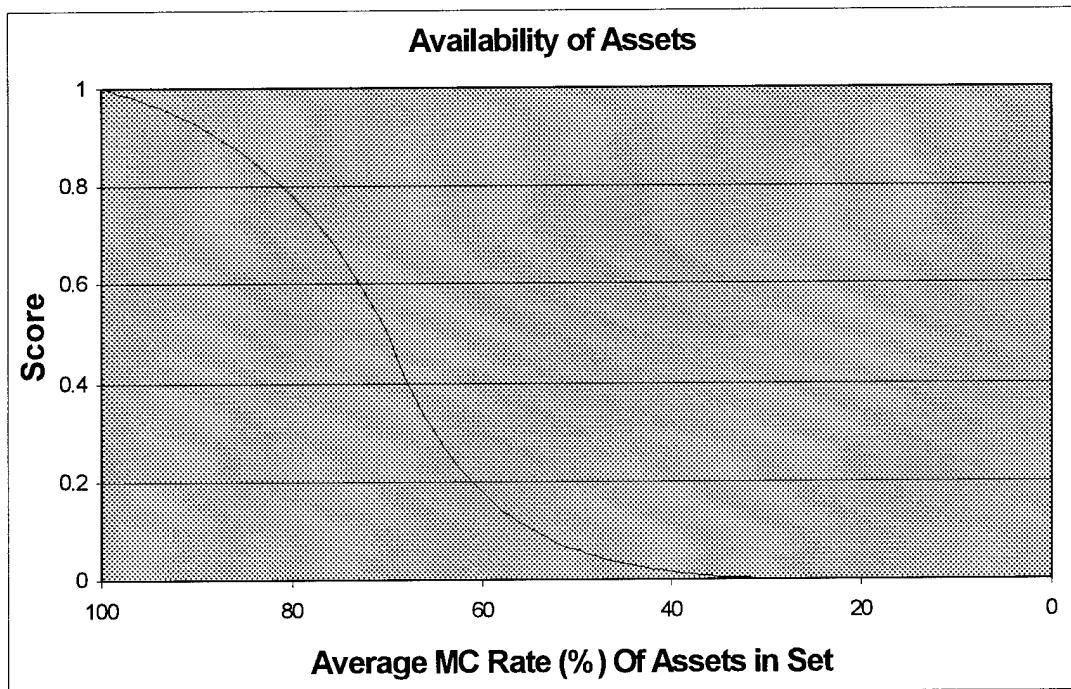
CALCULATION INFORMATION			
Avg Utility	Score		
0	0	1	
0.7	0.98		
1	0		
		Rho	-0.20766

Description: Extent to which each aircraft in the asset set is used to perform aerospace missions as required by the theater commander. This assumes that aircraft brought into the theater can be used to their operationally safe limit at a rate of 70 percent. Utilization rates higher than 70 percent can be damaging to the aircraft.

Measurement: "Percent Utility of All Aircraft in Asset Set." 0 – 100 percent. At 70 percent use of primary aircraft authorized, all assets in asset set are being used to their peak operational efficiency. This could be experienced during an initial surge of sortie activity, where USAF combat aircraft have been tasked to halt enemy action. At 100 percent used of primary aircraft authorized, aircraft in asset set have been surged to theoretical maximum, whereby all of the aircraft in the asset set are in a state of continual "turn and burn." 100 percent use of primary aircraft authorized cannot be sustained, as it will quickly degrade the capability of the aircraft assets to perform the mission. The entire range of percentages of use of primary aircraft authorized is possible.

Confirmed: 14 JAN 00 by CENTAF

AVAILABILITY OF ASSETS



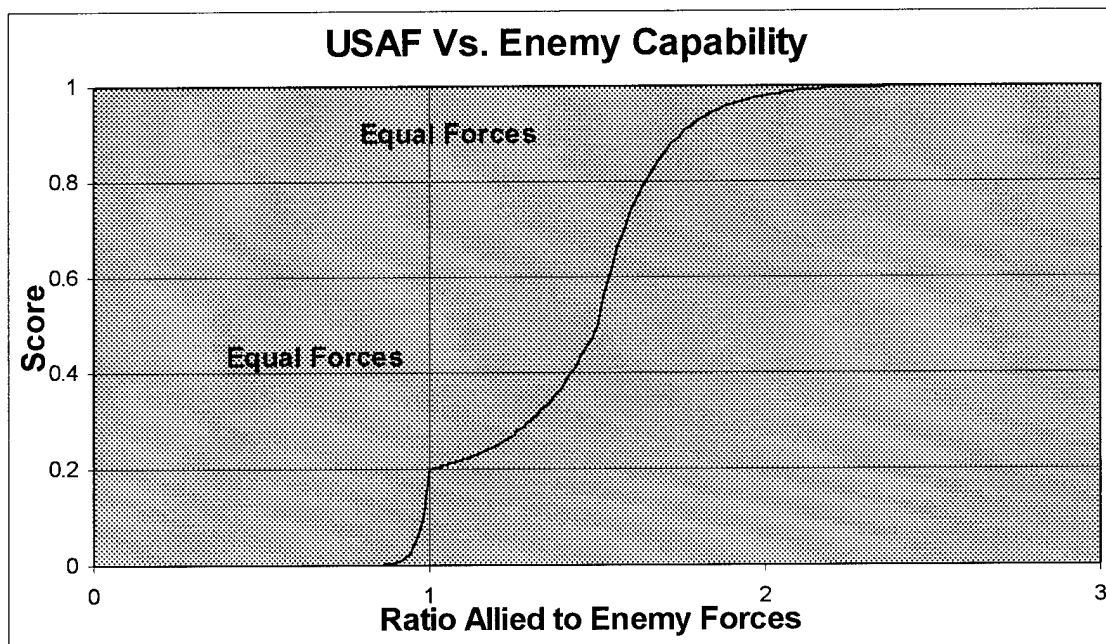
CALCULATION INFORMATION				
MC Rate				
%	Score			
0	0			
0.3	0			
0.7	0.5	Rho	-0.1	
1	1	Rho	0.15	

Description: Extent to which aircraft assets in the asset set are operationally capable of being used to conduct aerospace missions required by the theater commander.

Measurement: "Average Mission Capable Rate of Assets in Set." 0 – 100 percent. At 100 percent average mission capable rate, all of the assets in the set of assets have a 100 percent mission capable rate. This would mean that maintenance and repair requirements for each individual aircraft in the asset set could be completed without reducing the Mission Capability rate. At 0 percent average mission capable rate, all assets in the set of assets are non-flyable. This should be a theoretical minimum, because under circumstances where all of the assets in the asset set were grounded due to maintenance, another set of aircraft would be chosen. At 50 percent average mission capable rate, some assets may have a mission capable rate higher than 50 percent, while some assets may have a mission capable rate less than 50 percent. The entire range of percentages of availability of assets is possible.

Confirmed: 14 JAN 00 by CENTAF

USAF VS ENEMY CAPABILITY



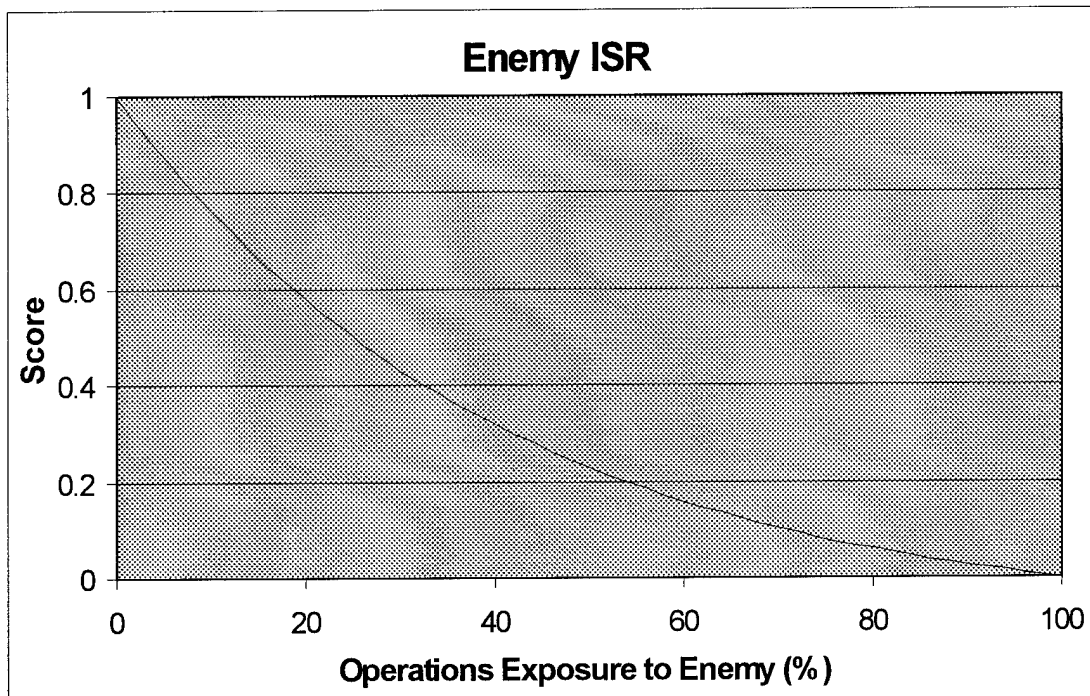
CALCULATION INFORMATION			
Ratio Enemy Capability to Number of Assets	Score		
0	0		
0.8	0		
1	0.2	Rho	-0.03
1.5	0.5	Rho	-0.22
3	1	Rho	0.155

Description: This factor measures comparison of enemy assets to USAF combat aircraft assets. Assuming US intelligence can determine extent of enemy capability, measure shows relative worth of amount of aircraft assets brought into pre-determined staging base. One issue is number of USAF combat aircraft brought into staging base; another issue is capabilities of enemy to counter USAF combat aircraft brought into staging base.

Measurement: "Ratio of Allied to Enemy Forces." 0 – 3. As ratio goes to 0, enemy capability vs. capabilities of combat aircraft in asset set increase (i.e., capability of 1 enemy MIG may equal capabilities of 3 US F-15s). As ratio goes to 1, capability of enemy forces and USAF combat aircraft are equal (i.e., capability of 1 enemy MIG may equal capabilities of 1 US F-16). As ratio goes to 3, capabilities of USAF combat aircraft exceed capability of enemy forces (i.e., capability of 3 enemy MIGs may equal capabilities of 1 F-117).

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ENEMY ISR



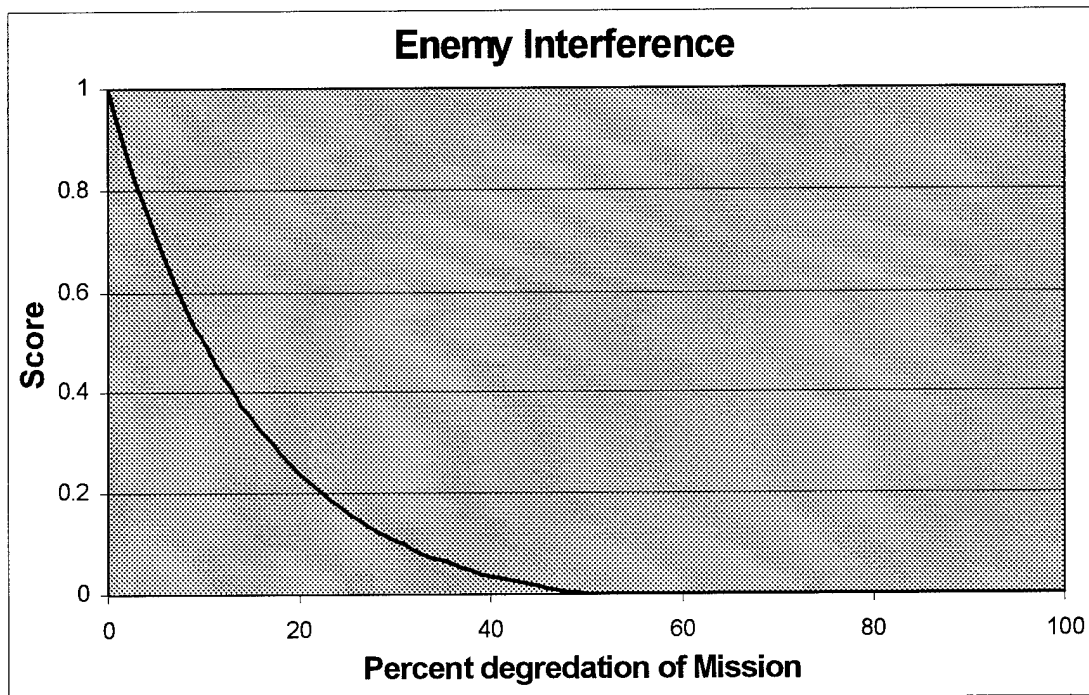
CALCULATION INFORMATION			
Enemy ISR	Score		
0	1		
1	0	Rho	-0.41

Description: This measure captures the enemy's ability to see or obtain information on US activity at the pre-determined staging base. Enemy ISR could be obtained through aerial or satellite photography, local sympathizers monitoring US activity, or spies within the host-nation working within or around the staging base.

Measurement: "Activity Exposure." 0 – 100 percent. At 0 percent exposure, the enemy has no intelligence on or ability to see our operations. This may occur due to the enemy's lack of ISR capabilities or due to strict secrecy of operational activity at the staging base. At 100 percent exposure, the enemy has full knowledge or visibility of our operations. 100 percent exposure is more conceivable than 0 percent exposure, as the presence of US combat aircraft at a staging base not usually hosting US forces would arouse some suspicion and concern of enemy leadership. The entire range of percentages of activity exposure is possible, due to the capabilities of the enemy and the amount of local sympathy for the enemy.

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ENEMY INTERFERENCE



CALCULATION INFORMATION			
Enemy Affect	Score		
	0	1	
	0.5	0	Rho -0.15236
	1	0	

Description: This measure captures the enemy's ability to interfere with US operations at the pre-determined staging base. Enemy interference is any action on the part of the enemy that would hamper US combat operations. Enemy interference could range from picketing and loitering around the staging base, isolated attempts to gain access into the base and base operations, bomb threats, attacks on aircraft taking off and landing at the base, or attacks on the base itself.

Measurement: "Operation degradation." 0 – 100 percent. At 0 percent operation degradation, no enemy interference of any kind is experienced at the staging base. At 100 percent operation degradation, enemy interference has halted any and all combat operations, to include destruction of the staging base. 100 percent operation degradation is a theoretical maximum, because if an actual attack on the staging base were expected to occur, the aircraft would be re-located to a different staging base. The entire range of percentages of operation degradation is possible.

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APPENDIX J: Delphi Study Subject Matter Expert Pool

HQ/USAF

Col Robert Allardice, AF/XOPE
Col Wade McRoberts, AF/XOPS
Lt Col Alan Engler, AF/XOOC
Lt Col Kevin Foley, AF/XOPE
Lt Col Mark Anderson, AF/XOPW
Lt Col Jose Rivera, AF/XOPW
Lt Col Michael Davis, AF/XOPX
Maj Karen Kwiatkowski, AF/XOPX

CENTAF

Mr Phillip Lamm, 69 CPS/DOXL
Maj Steve Luxion, 69 CPS/DOX
Lt Col William Doneth, 69 CPS/DOXL
Lt Col Gary Rattray, 49OSS/OSTE;

ACC

Col James Ruth, ACC/XOX
Col Stephen E. Wright, ACC/XOD
Lt Col Bill Reynolds, ACC/XOXC
Lt Col Alex Cruzmartinez, ACC/XOX
Maj Larry Hahn, ACC/XOX
Maj Joe Torres, ACC/XOX
Maj Lawrence Averbeck, ACC/XOXD
Capt. Jennifer J Murphy, ACC/XOXD
Mr. George Nelson, ACC/XOOS
Mr. Jeffrey Williams, ACC/XOOS

AU

Lt Col Q. C. Walters, CADRE/WSJ
Maj Michael Odowd, CADRE
Maj Leletta V. Tatum, CADRE/WSC

APPENDIX K: Comments from First Delphi Study Questionnaire

- Vertical hierarchy ignores the significant horizontal inter-relationships that affect the measures of merit in your definitions
 - I.e. contextual considerations not pertaining to beddown location may make a more distant location more effective
- Oversimplified BOS concerns; Security, Communications, Civil Engineering, Water Source, Billeting, etc. must also be considered
- *Staging Base* Issues should be considerations under *Beddown Location*
- Place *beddown location* higher than *multi-national compatibility* under *host-nation* column
- Factors, as listed, are not presented in priority order
 - Third-tier 'parent' issues are not addressed in their priority order
 - Sub-issues under each 'parent' issue are not addressed in their priority order
- Remove the term *staging base*; use *beddown location*
- Move *fighter/bomber distance* and *ability to resupply* to underneath *beddown location*
- Do not separate *fighter/bomber munitions*
- Due to theater, not just beddown location requirements;
 - Remove the term Munitions Storage Area; use Munitions stockpile availability and storage facilities
 - Remove the term POL; use POL stockpile, storage and dispensing capability
- Appears correct for the fighter/bomber arena
- Not suitable for application to a peace operation, smaller scale contingency, or a humanitarian assistance operation
- *Politics* and *Enemy* are inseparable and should be reflected as related; certainly they do not stand alone
- Need better definition of whose *intra-national politics* is being discussed; unclear if it is between US, NATO, UN, or enemy country
- Need to add a block for "Enemy Offensive Counter Air Capability"

APPENDIX L: Background paper for Delphi Weighting Interviews

BACKGROUND PAPER ON CAMPAIGN SPECIFIC ISSUE WEIGHTING INTERVIEW

1. The purpose of the research interview is to obtain opinions and knowledge on the relative weightings between the campaign specific issues identified during previous interviews and research. The purpose of this background paper is to provide an understanding of the process of the interview and to present an example of how the interview will be conducted.

- Previous rounds of Delphi study have determined relative ranking of Campaign Specific Issues

- Identified from interviews with campaign planners from HQ/AF, ACC, Air University, and CENTAF

- Ranking, based on level of importance, of issues has been determined

- Interview will consist of comparing 15 sets of two separate campaign specific issues to determine relative weight of all issues

2. To understanding how comparisons will be conducted, an example is provided. When deciding to purchase a car, many features must be considered. Consider two cars; Car 'A' has all 3 of the safety features required (i.e. anti-lock brakes, traction control, and dual air bags), and costs \$25,000. Car 'B' has 1 of the 3 safety features (dual air bags) needed, and costs \$20,000. For simplicity, other features will be disregarded.

- First, the value of these issues (safety features available and cost) based upon personal requirements must be identified.

- Determine 'value' for the price of the car, based on personal requirements

- Paying \$20,000 or less is optimal, resulting in a value of 1.0 at \$20,000

- Paying \$30,000 or more is bad, resulting in a value of 0 at \$30,000

- Value decreases linearly between \$20,000 and \$30,000 (\$25,000 results in a value of 0.5)

- Determine 'value' for having safety features, based on personal requirements
 - Having all 3 safety features is optimal, resulting in a value of 1.0 for all three
 - Having none of the safety features is very bad, resulting in a value of 0.
 - Value decreases equally between 3 to no features (1 feature results in a value of 0.33, 2 features result in a value of 0.66)
- Using the example, 'Safety' value of Car 'A' is 1.0, and 'Cost' value is 0.5
- 'Safety' value of Car 'B' is 0.33, 'Cost' value is 1.0
- Next, relative weighting between two issues must be determined
 - It is determined that safety features are more important than cost
 - Compare 'range of measurement' of safety (0 to 3 features) to 'range of measurement' of cost (\$20,000 to \$30,000)
 - As safety features more important than cost, compare cost to safety by asking the following question:

WHAT PORTION OF THE 'RANGE OF MEASUREMENT' OF SAFETY
EQUALS THE 'RANGE OF MEASUREMENT' OF COST?
 - Question determines level of concern over reduced value between two issues
 - If cost *swings* from \$20,000 to \$30,000 (best value to worst value), what would be the equivalent loss in safety features.
 - Based on personal belief, it is determined a *swing* in cost from \$20,000 to \$30,000 (best value to worst value) is comparable (same level of unhappiness is felt) to a *swing* in losing 1 safety feature (going from 3 to 2 safety features)
 - Although we will not be discussing this in the interview, value analysis of the two choices continues with converting range of measurement to value.
 - It is determined that Safety features are 3 times as important as cost (1 times the entire range of cost = 1/3 entire range of safety)

-- Combining both issues to compare different cars, individual weights must sum to 1

$$\text{'Cost'} + \text{'Safety'} = 1$$

$$3 \times \text{'Cost'} = \text{'Safety'}$$

Combining two equations, $\text{'Cost'} + (3 \times \text{'Cost'}) = 1$, Therefore $\text{Cost} = 0.25$

-- Weight of 'Cost' is 0.25 and weight of 'Safety' is 0.75.

- Once values and relative weightings identified for two issues, individual cars can be compared to determine 'best value' car for the buyer

-- Comparison of different cars based upon summing the following to determine total value:

Value of 'Cost' x Weight of 'Cost'

Value of 'Safety' x Weight of 'Safety'

-- Using example, Car 'A' commands total value of:

$$(0.5 \times 0.25) + (1 \times 0.75) = 0.88$$

-- Car 'B' commands total value of:

$$(1.0 \times 0.25) + (0.33 \times 0.75) = 0.50$$

-- Therefore, based on value analysis, choose Car 'A' as car with highest total value

3. Over the course of this research, the ranges of measurement for each individual Campaign Specific Issue has been determined. The relative importance ranking of the Campaign Specific Issues have also been identified. The purpose of the interview is to obtain the relative weightings for these issues in the manner discussed in this paper.

4. Thank you very much for your time and support of this research effort. If you have any questions about the method in which the interview will be conducted or for any other reason, please do not hesitate to e-mail me at **Christopher.Buzo@afit.af.mil**.

1Lt Christopher Buzo/AFIT/ENV/(937)254-5895/9Feb00

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VITA

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From 1996 – 1998 he served as a civil engineering officer at Ellsworth AFB, South Dakota. He worked two major programs: he implemented the base solid waste recycling and disposal program and served as the 28th Civil Engineering Readiness Flight Commander.

In Aug 1998, he was accepted into the Master's program at the Air Force Institute of Technology. Upon graduation, he will be assigned to the Air Force Center for Environmental Excellence at Brooks AFB, TX.

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